DOCTORAL (PHD) THESIS

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CHEMICAL COMPOSITION, YIELD, NUTRITIVE VALUE AND MEAT HORSE KEEPING CAPACITY OF NON-FERTILEZED AND FERTILIZED GRASSLANDS

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1. BACKGROUNDS AND GOALS

Common agricultural policy of the EU prefers extensive or semi-intensive grasslands with medium fertilizer levels to intensive, highly fertilized ones. On grasslands of the preferred type it seems to be expedient to decrease the quantity of fertilizers (even to zero level)

Utilization of extensive and semi-intensive grasslands supposes obviously grazing. Bulk feed animal production in Hungary can exploit only 30% of its capacities. Unused potentials point out the possibilities of strengthening and diversifying bulk feed, grazed animal production sector. The task is to find the right species and right ways of utilization. Grazing based meat production assumes the usage of species previously being out of this circle such as slaughter horse.

Slaughter horse – especially slaughter foal – is a unique product that is out of the European production quotas, it is controlled only by consumption. Growing preferences toward healthy nutrition pull the demand upward and the product itself belongs to the group of higher price level goods. Export of slaughter horse products brought remarkable price income for Hungary in recent years.

According to studies it can be concluded that Hungarian cold blood horse can be successfully bred and kept on suitable pastures with conditions similar to beef production *(Gulyás, 1996)*.

Thesis focuses on analyzing the successfulness of grazing based horse meat production (as a reinvented sector) on fertilized and non fertilized grasslands. Since data on the effects of reducing fertilizers – under same conditions and with same grass types – can hardly be found in literature an experiment was set up on the pastures Study Farm of University of Kaposvár, Faculty of Animal Science.

According to the above the following goals and objectives were set:

1. Effects of zero fertilizing on nutrient content (macro- and micro elements) of soil
2. Comparing the yields of non fertilized and fertilized plots with respect to the followings:
   - chemical structure of grass
   - yield quantity per ha in raw weight and in dry material
   - calculating the yield in terms of nutrient quantity per ha (crude protein, digestible energy)
3. Finding relationships between yield, nutrient content and production level of animal products.

2. MATERIALS AND METHODS

Experiments were performed on the grasslands of the Study Farm of Kaposvár University between 1999-2000. D1 (32 ha) and D2 (25 ha) plots of the farm were chosen. First cut was harvested by a mower in order to utilize the surplus grass needed over the grazing. The area was partly fertilized (14.6 ha), the rest (26.4 ha) was kept as non treated control. Fertilizing parameters were as follows: yearly quantities per hectare, N 100 kg, P 40 kg, K 40 kg. Nitrogen was applied (in form of 34% ammonium-nitrate) in early March both years, phosphorous (18% superphosphate) and potassium (60% KCl) in November. For three years prior to the experiment the plots were treated with the indicated level of fertilizers.

At the beginning of the grazing season standard soil samples were taken *(MSZ-08 0202–77)* and full (TVG-line) chemical analysis was performed *(MSZ- 08 1722/ 1 – 3 : 1989)*.

All areas were segmented and used for grazing slaughter horses

Sampling to determine yield and nutritive value of the grass (*MSZ 6962 : 1984)* happened prior to moving the horses to new segments. Freshly utilized segments were sampled on 10 random spots using 0.5x0.5 m sampling frame and mow scissors cutting the grass evenly above 3 cm. Samplings were performed always by the same person.

Samples were taken immediately to the laboratory where the grass was weighted and after a predrying the dry material content was determined.

Yields of fertilized and non fertilized areas were calculated upon the green weight of the samples.

As for nutritive value, 5 average samples were formed per segments and they were analyzed parallely in Laboratory of Food and Service Division of Bóly Co.Ltd. Nutrient content analyzis happened under the frames of *MSZ*

6830 (Chemical .analysis of grass and other forages) while that of mineral content through *MSZ ISO 6490*

Upon the results of chemical analysis digestible energy (DE, MJ/kg) was calculated through the Harris formula.

Based on green yield per hectare and dry material content as well as nutritive value of grass the yield quantity in terms of crude protein, dry material and digestible energy was calculated.

Experimental and control horse stocks were grazed from 03 March to 19 October in 1999 and 26 April to 25 July in 2000 because after the given date the growth of the grass practically stopped so the animals had to be fed with hay. Grazing was possible again from mid September to 19 October.

In 1999 as much as 26 mares and progeny were introduced to non fertilized area while 20 and progeny to fertilized plots. In 2000 the fertilized areas were grazed by 20 mares and progeny and non fertilized ones by 22 mares and progeny. Animals in both groups were selected randomly. As for breed, most horses were Hungarian cold blood and there were some mares covered by imported French stallions. Batch mating was used for covering so the origination of foals was clear. Two stallions were used with mare groups of 20-26 each.

According to the set aims and objectives of the study the mares and foals were measured at the beginning and at the end of the grazing season. Average live weight gain and in case of foals daily weight gain was calculated per animal. Finally mare live weight corrected foal weight gain per one hectare grassland was determined.

Statistical analysis was carried out by using SPSS for Windows 8.0 software kit.

3. RESULTS

3.1. Comparing nutritive value of fertilized and non fertilized soils in 1999-2000

When comparing the treatments it can be concluded that in 1999-2000 the average nitrogen content of fertilized areas (15.8 ppm) was significantly, cca. 3 times higher than that of non fertilized ones (4,5 ppm). Connected to nitrogen the humus content was also higher in fertilized areas (1.83%) than in non fertilized ones (1.74%). Difference proved to be significant. As for humus supply, the non fertilized plots are very poor, the fertilized ones are poor.

In case of phosphorous and potassium contents the results are quite diverse. The P_2O_5 content was higher in control areas (346 ppm) than in fertilized ones (297 ppm) and phosphorous supply of the soil proved to be very good in all treatments.

The K_2O content was higher in fertilized areas (169 ppm) than in non fertilized spots (145 ppm).

No remarkable differences could be observed between the micro element contents of control and treated soils.

3.2. Comparing yield, nutritive content of fertilized and non fertilized grasslands in 1999-2000

Combined results of chemical analysis in two consecutive years of the actual cuts show the following tendencies. (Table 1.)

3.2.1. Comparing nutritive content of fertilized and non fertilized areas in 1999-2000

Table 1: Weende analysis of first- and aftergrass in 1999-2000

Cuts	Year	Treatment	n	dry material %	crude protein %	raw fat %	raw fibre %	raw ash %	N free extract. %	raw fibre /crude protein	DE (horse) MJ/kg
					in % of dry material						
A	1999	Control	10	15,3	16,4	3,2	27,1	9,3	44,1	1,65	9,6
A	1999	Fertilized	10	15,2	17,4	2,4	26,6	8,5	45,2	1,53	9,7
S1	1999	Control	20	20,7	17,1	2,6	28,1	9,8	42,4	1,64	9,4
S1	1999	Fertilized	20	18,5	18,2	2,8	26,7	10,1	42,3	1,47	9,6
S2	1999	Control	20	24,7	18,5	2,9	25,0	9,9	43,7	1,35	9,8
S2	1999	Fertilized	15	24,0	20,0	2,7	24,9	9,1	43,3	1,25	9,9
S3	1999	Control	5	35,1	16,5	2,8	22,2	12,0	46,8	1,35	9,7
S3	1999	Fertilized	10	18,7	21,9	2,9	23,8	10,0	41,6	1,09	10,1
A	2000	Control	15	29,9	14,1	3,1	26,9	8,5	47,3	1,91	9,5
A	2000	Fertilized	15	27,1	16,5	3,1	25,4	8,2	46,8	1,54	9,8
S1	2000	Control	15	41,0	12,0	3,6	29,1	7,4	47,9	2,43	9,3
S1	2000	Fertilized	15	31,6	17,5	3,5	26,7	8,6	43,7	1,53	9,7
S2	2000	Control	10	20,2	17,9	4,0	23,9	9,4	44,8	1,34	10,0
S2	2000	Fertilized	10	18,2	22,2	4,3	21,2	10,9	41,7	0,95	10,4
Mean		**Control**	**95**	**26,7** [a]	**16,1** [a]	**3,2**	**26,0** [a]	**9,5**	**45,3** [a]	**1,67**	**9,6** [a]
		Fertilized	**95**	**21,9** [b]	**19,1** [b]	**3,1**	**25,0** [b]	**9,3**	**43,5** [b]	**1,34**	**9,9** [b]
		fertilized / control		**0,82**	**1,19**	**0,98**	**0,96**	**0,99**	**0,96**	**0,80**	**1,03**

a (control) b(fertilized) significant difference between data (P ≤ 0,05)

It can be concluded that dry material content of grass on non fertilized area was higher (26.7%) than that of the grass on fertilized spot (21.9%). The difference between them is significant (P≤ 0,05).

Crude protein was higher in samples from fertilized spots. Difference is 19% and it proved to be significant (P ≤ 0,05). This actual increment is much higher than the value published by Pálinkás *(1997)* stating that raising nitrogen by 50 kg/ha is followed by crude protein increase of 5-6%.

Same author *(Pálinkás, 1997)* says that 50 kg/ha nitrogen surplus dropped back raw fibre content by 2-3%. This particular decrease could not be

observed in our experiment. Raw fibre content showed 1% (4% in relative terms) – statistically proven – difference between treatments.

In the average of the two years the raw fat contents of the samples from fertilized and non fertilized spots were practically the same, 32-31 g/kg dry material.

In contrary to the tendencies published previously *(Nagy, 1991)* our experiment showed that as an effect of fertilizing not only N-free extractables dropped but so did raw ash value. In case of raw ash the difference was not significant.

Digestible energy was in all cases higher in samples from fertilized areas (9.9 MJ/kg dry material) than in non fertilized samples (9.6 MJ/kg dry material). The difference was significant.

3.2.2. Comparing yield quantity of fertilized and non fertilized grass in 1999-2000

Due to severe drought in 2000 the yields of treated and control plots remarkably dropped in comparison the values of previous year.

Data in Table 2 show that decrease of yield per hectare on fertilized areas in 2000 was 7% in terms of green weight, 12% in dry material, 1% in crude protein and 11% in digestible energy.

Green yield of fertilized areas was 32% higher (8062 kg/ha) than that of non fertilized areas (6076 kg/ha). Fertilized grassland in the experiment can be taken an extensive one even despite the additional 100 kg/ha N-treatment because – as it was stated by Szűcs and Tóth *(2003)* – a grassland is extensive if its yield level is below 5.35 tons/ha dry material.

In terms of dry material and crude protein the results of fertilized grass were better. dry material yield was 1615 kg/ha on fertilized areas and 1358 kg/ha on non fertilized areas.

Crude protein yield in the average of the two years was 285 kg/ha on fertilized plots and 213 kg/ha on non fertilized ones.

Digestible energy was 15753 MJ and 12953 MJ on one hectare of fertilized and non fertilized areas, respectively.

Table 2: Average yield of first- and aftergrass in 1999-2000

Cuts	Year	n	Treatment	Green yield kg/ha	Dry material yield kg/ha	Crude protein yield kg/ha	DE (MJ / ha)
A	1999	20	control	15422	2345	374	22278
A	1999	20	fertilized	18904	2929	458	27957
S1	1999	40	control	7335	1512	256	14220
S1	1999	40	fertilized	10360	1848	329	17658
S2	1999	40	control	3720	950	166	9211
S2	1999	30	fertilized	7673	1932	365	19090
S3	1999	10	control	4040	1248	210	12106
S3	1999	20	fertilized	5060	919	202	9282
Total	**1999**	**110**	**control**	**7629** [a]	**1514** [a]	**252** [a]	**14454** [a]
Total	**1999**	**110**	**fertilized**	**10499** [b]	**1907** [b]	**339** [b]	**18497** [b]
A	2000	30	control	7813	2161	310	20464
A	2000	30	fertilized	8450	2194	353	21412
S1	2000	30	control	2003	827	98	7715
S1	2000	30	fertilized	2533	788	140	7692
S2	2000	20	control	2200	462	78	4550
S2	2000	20	fertilized	3455	695	152	7183
Total.	***2000***	***80***	**control**	***4006***	***1150***	***162*** [a]	***10910***
Total.	***2000***	***80***	**fertilized**	***4813***	***1226***	***215*** [b]	***12095***
Mean	**1999-2000**	**190**	**control**	**6076** [a]	**1358** [a]	**213** [a]	**12935** [a]
	1999-2000	**190**	**fertilized**	**8062** [b]	**1615** [b]	**285** [b]	**15753** [b]
			fertilized / control	**1,33**	**1,19**	**1,34**	**1,22**

a (control) b (fertilized) significant differences ($P \leq 0,05$)

The differences between the yields (expressed in green weight, dry material, crude protein and digestible energy) are significant.

Green yield of one hectare fertilized grassland could be produced on 1.33 ha non fertilized land, dry material yield on 1.19 ha, crude protein yield on 1.34 ha and digestible energy yield on 1.22 ha.

3.3. Weight gain of mares and foals kept on fertilized and non fertilized grasslands in 1999-2000

Two years average change of weight gain data of animals kept on fertilized and non fertilized pastures follow the same pattern as the change in the individual years. Cumulated data show that more favorable nutrient content of fertilized grass had an effect on foal weight gain per feeding day and animal product (horse meat) per one hectare values. (Table 3, Figure 1.)

Table 3: Growth of foals, live weight gain of mares

Year	1999	1999	2000	2000	1999-2000	1999-2000
Grass treatments	control	fertilized	control	fertilized	control	fertilized
live weight gain of foals in grazing season kg/foal	224 (n=20)	233 (n=17)	204 (n=17)	212 (n=15)	214 (n=37)	223 (n=32)
weight gain of foals g/day (without birth weight)	1085	1184	1026	1056	1056	1120
weight gain of foals g/day (with birth weight)	1417	1509	1352	1379	1385	1444
Weight change of mares in grazing season kg/mare	-26 (N=26)	-21 (n=20)	-33 (n=22)	-28 (n=20)	-30 (N=48)	-24 (n=40)
live weight gain of foals in grazing season kg/ha	169[a]	271[b]	132[a]	218[b]	151[a]	245[b]
Weight change of mares in grazing season kg/ha	-26	-28	-27	-38	-27	-33
Weight change of mares and foals in grazing season kg/ha	143[a]	243[b]	105[a]	180[b]	124[a]	211[b]

a (control) b (fertilized) significant differences ($P \leq 0,05$)

Inferior results of daily weight gain and meat productivity per hectare in year 2000 can be explained by a number of factors. Due to the severe draught the grass burnt out and despite the given hay provided suitable daily weight gain (1056 g/day on fertilized and 1026 g/day on non fertilized areas), the actual values remained below the results of the previous year (1184 g/day on fertilized and 1085 g/day on non fertilized areas). Also, weight drop of mares was higher in 2000. Less meat production per hectare was caused also by smaller mare stock and fewer foals born. In 1999 there were 20 foals on fertilized and 17 on non fertilized spots, while in 2000 the same values are 17 and 15 (Table 4.).

Rate of effective progeny was acceptable in the experiment. According to *Makray* and *Stefler (2004)* the production with about 70% effective progeny cannot be profitable, while with an over 75% rate the economic parameters are favorable. In the experiment the same rate was 75-85%.

Table 4: Rate of effective progeny in 1999-2000

	control plot			**fertilized plot**		
	mare (head)	**foal (head)**	**effective progeny (%)**	**mare (head)**	**foal (head)**	**effective progeny (%)**
1999	26	20	77	20	17	85
2000	22	17	77	20	15	75
1999-2000	48	37	77	40	32	80

As a summary it can be stated that the horse meat quantity produced on one hectare of fertilized grassland can be repeated on 1.7 ha of non fertilized pasture.

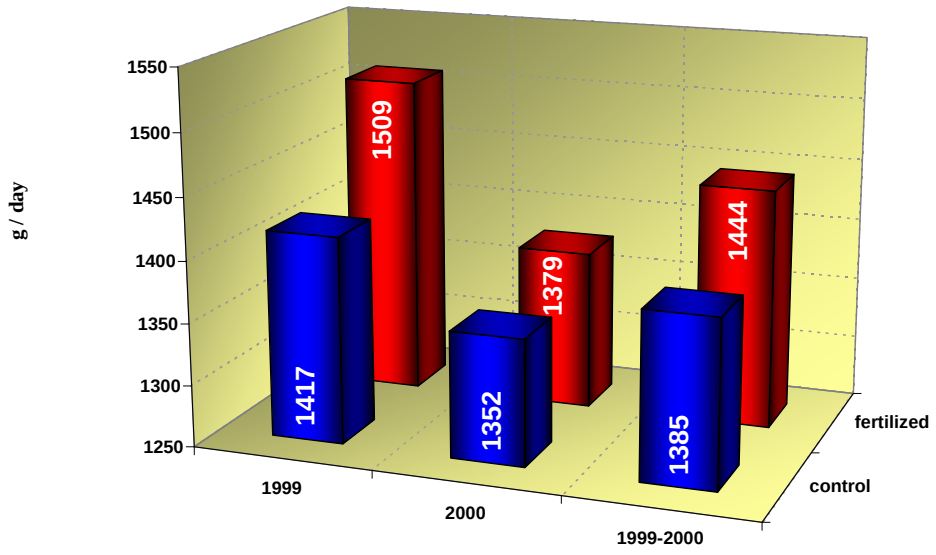

Fig 1: Live weight gain of foals (incl. weight at birth) (g/day)

4. CONCLUSIONS

- *Nutrient content of the soil*

Due to nutrient supplement (100 kg N, 40 kg P and 40 kg K per hectare) the nitrogen content of fertilized soil was higher (15,8 ppm) than that of the non fertilized (4,5 ppm). The difference is significant. Humus content was also higher 1.83 and 1.74%, respectively. As for phosphorous and potassium content, the picture is more confused, however phosphorous supply was favorable in both fertilized and non fertilized soil. Potassium content was higher on fertilized areas in 1999-2000. In case of micro elements no remarkable difference was found in the samples.

- *Nutrient content of grass*

Effects on fertilizing on nutrient content of grass can be summarized as follows.

Dry material content was higher in samples from non fertilized land, the difference between them was significant ($P \leq 0,05$).

Crude protein was higher by 19% in samples from fertilized areas, the difference was again significant ($P \leq 0,05$).

In contrary to the values published earlier by Nagy (1991) the difference between raw fibre contents of the samples from the treatments was only 1% (relative 4%) and this difference proved to be significant.

In the average of the two years the raw fat content of the grass from the treatments was similar. In contrary to data published in our experiment the application of fertilizer reduced not only the N-free extractables but also the raw ash content, however the difference in case of the latter was not significant.

Digestible energy was in all cases higher in fertilized grass (9.9 MJ/kg dry material and 9.6 in case of non fertilized grass). The difference was significant.

- *Yield quantity*

Analysis of productivity of fertilized and non fertilized grass showed that the green yield of the former is 32% higher (8062 kg/ha) than that of the latter (6076 kg/ha) in the average of two years.

The difference between the yields of fertilized and non fertilized grasslands was significant and could be justified either in terms of green weight or dry material or crude protein or digestible energy. Yield of one hectare fertilized grassland (in any yield terms) could be reproduced about 1.2-1.3 ha of non fertilized land.

In the dry year of 2000 the green yield decreased even by 50%. If compared to the values of 1999 the yield terms (green yield, dry material, raw protein, digestible energy) of fertilized land showed stronger decrease than the non fertilized areas.

- *Animal production (meat production)*

Weight gain and meat production data of animals grazed on fertilized and control areas showed the positive effects of higher nutrient content of grass on fertilized land. Both daily weight gain of foals and meat output per hectare values were higher in that case. Other production parameters of the animals on fertilized pastures were also better.

Rate of effective progeny ranged 75-85% in our experiment which is quite favorable in Hungarian conditions *(Makray-Stefler, 2004)*. Live weight gain of mares and foals showed that the horse meat quantity produced on one

hectare of fertilized grassland can be regenerated on 1.7 ha of non fertilized pasture.

On non fertilized pastures a mare and her foal require 1.1 grazing land while on fertilized plots 0.73 ha is enough. Keeping capacities of grasslands in South-Transdanubia can be determined between the above values.

5. NEW AND PROGRESSIVE SCIENTIFIC RESULTS

- Fertilizing influences mainly the crude protein content of grass. Within the conditions of South-Transdanubia applying active ingredients 100kg N, 40kg P and 40kg K on *Lolium perenne* + *Dactylis glomerata* grassland resulted – without irrigation – in a crude protein increase of 30 g/kg dry material as compared to non fertilized spot.
- Omitting fertilizing remarkably drops the yield back. According to the experimental results the green yield of 1 ha fertilized grassland can be produced on 1.33 ha of non fertilized area; the same for dry material, crude protein and digestible energy are 1.19, 1.34 and 1.22, respectively.
- Results showed that a mare and a foal require 1.1 ha of non-fertilized grassland during the grazing season, while 0.73 ha is needed if the spot is fertilized.
- Calculation of animal keeping capacity – based on the mare live weight corrected foal weight gain – shows that in South-Transdanubia the meat yield of 1 ha fertilized grassland can be produced on 1.7 ha non fertilized area.

The latter fact points out that the calculation of animal keeping capacity of grasslands has to involve not only the productivity of the grass but also the losses occurring through feed transformation processes

6. SUGGESTIONS

The above outlined experiment was initiated by the fact that cost sensitive animal production technologies and also the respective regulations of the EU focus on reduced usage of chemicals on grasslands.

Upon the results of the survey recommendations can be made for animal producers (especially for grazing based slaughter horse producers) on the effects of reduced (or zero level) fertilizer usage on pastures, what consequences it has concerning the grass yield (taken in green weight, dry material crude protein and digestible energy), nutrient content as well as animal keeping capacities of South-Transdanubian grasslands.

Results show that reducing fertilizer dosage cuts back the productivity and animal keeping capacity of the plot, however, increasing the non fertilized production area can ensure profitable operation.

Quantity of meat produced on a hectare of fertilized pasture requires remarkably more area (1.7 ha) of non fertilized land and this difference is bigger than it was observed in the case of changes in green mass productivity where one hectare dry material and crude protein output of 1 ha fertilized land could be covered by 1.19 and 1.34 ha of non fertilized area, respectively.

Our results highlight the fact that calculations of keeping capacities of grasslands assume the involvement of losses occurring through feed transformation processes.

7. PUBLICATIONS RELATED TO THESIS

Publications in Hungarian

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