Effects of beneficial micro-organisms (EM) First results experimental farm "De Ossekampen" in Wageningen.

Introduction

Nutrient utilization efficiency of nitrogen (N) in Dutch dairy farming is extremely low. The ratio of N in product (milk, meat) to N from external inputs (concentrates, fertilizer) has decreased from more than 0.30 in the 1950/60s to less than 0.20 currently. This drastic decrease is primarily related to intensification.

The question can be raised whether it would be possible to environmentally tune intensive dairy farming systems, while maintaining level of production per hectare? According to a recent analysis of the N flows of various dairy farms, production is most sensitive to (1) nutrient uptake from the soil (sensitivity 1-1.5), (2) nutrient conversion in the animals (0.8-0.9), (3) fertilizer supply (0.4-0.6), and (4) concentrate inputs (0.3-0.5). The sensitivity coefficients denote a percentage response (%Y) to a percentage change (%X) in sub-system (soil/animal) nutrient use efficiencies or a percentage change in external inputs, viz. concentrates and fertilizer. On the other hand, the N surplus is most sensitive to fertilizer input (0.6-0.8), concentrate input (0.2-0.3) and nutrient uptake from the soil (0.2-0.3). Nutrient use efficiency at animal level shows only a minor effect (0.1-0.2). Therefore, in the case of N, most effective interventions should aim at a gradual reduction in fertilizer input, while upgrading N uptake from the soil, *i.e.* the biological functioning of the soil.

Thus far, disciplinary research focusing on improving the output of sub-systems in isolation, *e.g.* forage yield, milk production and feed conversion, has led to production systems with an overall lower nutrient use efficiency. Negative interactions (antagonisms) among sub-systems can be held responsible, e.g. manure of high-yielding dairy cows may have a negative impact on the biological functioning of the soil. This justifies the conclusion that experiments carried out in isolation from their natural context cannot possibly yield any information on interrelations among sub-systems. For a longer-term effective solution, an integrated approach is needed, studying nutrient cycles at farm, *i.e.* soil-plant-animal level.

To improve the organic matter status and biological functioning of the soil, various measure can be considered, *e.g.* (1) improving the quality of manure, *i.c.* increasing its C/N ratio, (2) protecting soil organic matter and microflora by clay minerals, (3) balancing the microbial environment by adding a microbial community (*e.g.* EM), and (4) by including energy/information carriers (*e.g.* according to Plocher). Below, the first results are described of a combination of treatments 2 (soil) and 3 (soil/forage/silage/animals).

Objectives

To study the effect of a microbial community (effective micro-organisms) on:

- yield and composition of grass (silage)
- yield and composition of milk
- VFA profile in rumen
- growth rate of young stock

Results

Experimental farm "De Ossekampen" comprises approximately 70 hectares of grassland on heavy clay. The soil is not so suitable for arable farming. Occasionally, in the process of improving pastures (tillage, resowing), silage maize is used as an intercrop.

To test Effective Micro-organisms, the farm has been devided in two parts, of 30 and 40 hectares, respectively. Each part is made up of four blocks, with the soil composition and chemical fertility about comparable (Table 1). Fertilizer supply between EM and control pastures is kept equal. The amounts of EM and control slurry supplied are comparable. The EM pastures were sprayed with EM1 (1 ltr ha^{-1}) in March, May, September and October, respectively.

Table 1. Soil characteristics

	EM	Control
pH	5.1	5.0
organic matter (%)	13.5	13.4
P-AL	22.0	20.1
K	24.6	25.1

During the stall period a pilot experiment has been carried out with two groups of 17 dairy cattle. One group was fed a basal diet of maize silage and grass silage, and the other grass silage and barley straw, thoroughly mixed in a mixing wagon. The first half of the experiment, *i.e.* 6 weeks, the animals were denied EM. In the consecutive period of 6 weeks, per cow and day 250 g EM-bokashi was included in the mixing wagon. To sample rumen fluid, two rumen fistulated animals were included in each experimental group.

Over this short period, no clear effects were observed with respect to milk composition and the relative proportions of the volatile fatty acids produced in the rumen (Table 2). There was no interaction between the composition of the basal diet and inclusion of EM bokashi.

Table 2. Rumen and milk characteristics

		EM	control
rumen	acetic acid[1]	67.6	65.6
	propionic acid[1]	16.5	17.7
	butyric acid[1]	12.8	13.5
	isobutyric acid[1]	0.7	0.7
	valeric acid[1]	1.3	1.0
	isovaleric acid[1]	1.1	1.5
	ammonia (mg.ltr^{-1})	210	180
milk	production (kg.d^{-1})[2]	23.5	23.1
	fat (%)	4.76	4.47
	protein (%)	3.32	3.33

[1]) mol percentage; [2]) corrected for time delay

Conclusion: EM does not affect the volatile fatty acid profile in the rumen. Ammonia and isovaleric acid show a tendency to increase, possibly because of an increased proteolytic activity. EM did not significantly affect milk yield and composition.

In May 1997, two herds of dairy cattle have been composed, denoted “EM” and “control”, respectively. 21 Pairs of dairy cattle have been selected, based on production, parity, stage of lactation and lactation value. Parity of the EM herd was slightly higher but breeding value lower. An overview is presented in Table 4. On a daily basis, the EM cows were offered 0.5 kg EM bokashi. Starting June, milk production has been recorded on a daily basis, and fat and protein contents on a biweekly basis. Around May 20th, the EM cattle were transferred to pasture 12, in which meanwhile the 1st cut grass had become a bit mature for grazing. As a result, in the first half of June the EM group produced slightly less milk than the control group, while milk fat content was higher. In the month July, hardly any difference was noticed between both groups, both in terms of milk yield and composition. Gradually, however, it became apparent that the physical condition of the EM cows improved. Starting August, the milk yield of the EM cows was higher, compared to their controls. The experimented was terminated at the end of December, when in both groups 10 dairy cows were left, The others had meanwhile been dried off for the subsequent lactation cycle. The results have been summarized in Table 3.

Table 3. Cow characteristics and milk yield/composition.

	EM				control			
parity[1]	1.9				1.8[2]			
days in lactation[1]	156				153			
lactation value[1]	100				104			
breeding value (INET)[1]	65				107			
milk yield		fat	prot	lact		fat	prot	lact
May (start)	23.3				23.3			
June	21.6	4.25	3.26	4.67	22.2	4.09	3.35	4.51
July	21.7	3.91	3.33	4.52	21.5	3.98	3.28	4.54
August	21.2	4.09	3.35	4.60	19.7	3.97	3.31	4.47
September	21.2	4.04	3.39	4.57	19.3	4.34	3.47	4.36
October	21.0	4.27	3.56	4.60	18.1	4.46	3.70	4.48
November	19.5	4.79	3.59	4.53	17.0	4.87	3.70	4.35
December	15.8	4.64	3.52	4.58	13.7	4.83	3.61	4.38
June-December	20.3	4.26	3.42	4.58	18.8	4.32	3.47	4.45

[1]) first half of June; [2]) 1(heifer), 2 and 3 (for 3 and higher)

Conclusion: Starting August, the production of the EM herd was higher, on average over the period June-December 1.5 kg.cow^{-1}.d^{-1}. Fat and protein contents tended to be lower and lactose higher.

In total, about 75 hectare have been cut for silage. A summary is presented in Table 4. The EM grass appears to earlier mature. This can be seen from the composition of the silages. In the EM silages, the NEL, CP and sugar contents are slightly lower, crude fibre (CF) content slightly higher. In the EM silages, dry matter (DM) content is lower, but this can be attributed to the somewhat cooler field days. In the EM silage, the ammonia fraction is higher than acceptable.

Table 4. Dry matter yields and silage characteristics.

	EM	control
# hectare	43.4	30.8
dry matter yield (ton.ha^{-1})	7.0	6.8
silage crude protein (% DM)	15.0	16.1
NEL[1] (MJ kg^{-1} DM)	5.3	5.8
ammonia fraction[2]	10	7
crude fibre (% DM)	29.6	27.0
sugar (% DM)	2.0	6.3

[1]) Net Energy for Lactation; [2]) norm < 7

Two groups of young stock have been formed. The animals were selected, based on (1) age, (2) predicted production level (INET) and (3) predicted day of parturition. The EM group, including dry cattle, is offered an EM pasture until December 9th. Thereafter, the animals were kept in the animal house. Growth rates are summarized in Table 5.

Table 5. Characteristics young stock.

	EM[1]	EM[2]	control[1]	control[2]
number	5	6	5	9
age at onset (d)	528	345	497	352
live weight (kg)				
August 15	425	315	416	308
December 9	514	408	485	386
February 24	587	465	558	453
growth rate (g.d^{-1})				
15/8 - 9/12	767	802	595	672
9/12 – 24/2	948	740	948	870
15/8 – 24/2	839	777	736	751

[12]) age groups

Conclusion: In pasture, EM young stock showed a higher growth rate. The growth delay in the control group was partly compensated in the stal period.

Overall conclusions:

- It is far to early for drawing firm conclusions. Therefore, the conclusions below are of a tentative nature.
- The experiment carried out in an integrated context showed some results, which did not emerge form disciplinary experiments.
- The EM dairy cattle showed a better condition, a slightly higher milk yield and slightly lower fat and protein contents.
- The EM young stock showed slightly higher growth rates in pasture; this difference was partly compensated in the stall period.
- No significant difference in grass dry matter yield was observed; EM silage had a higher crude fibre content, a lower sugar content and a lower NEL (net energy lactation) value. EM silage showed also a higher ammonia value, an indication

for more protein degradation.

- It is still too early to draw any firm conclusion about nutrient availability from the soil. Further research is recommended, to be carry over longer period of time in an integrated soil-plant-animal context. Such research is urgently needed to disprove the hypothesis that Effective Micro-organisms cause a rapid mineralization of soil organic matter.

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