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Economic potential of milk production strategies with restrictive use of concentrated feed—An experiment on 36 family farms in the pre-alpine region

Christian Gazzarin[1] | Bruno Häller[2] | Pius Hofstetter[3]

[1]Managerial Economics in Agriculture, Agroscope Tänikon Research Station, Ettenhausen, Switzerland

[2]HAFL Zollikofen, University of Applied Sciences Bern BFH, Zollikofen, Switzerland

[3]BBZN Lucerne, Vocational Education and Training Centre for Nature and Nutrition, Lucerne, Switzerland

Correspondence
Christian Gazzarin, Agroscope Research Station, Tänikon, CH-8356 Ettenhausen, Switzerland.
Email: christian.gazzarin@agroscope.admin.ch

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Abstract

The objective of this study was to quantify the economic potential of grass-based milk production strategies with limited use of concentrated feed in the pre-alpine region. We monitored 36 family dairy farms from the pre-alpine region of Switzerland divided in three study groups following one of three defined, voluntarily adopted production strategies: Partial grazing and barn feeding with freshly cut forages, supplementing <500 kg (GBF) and 1,200 kg (GBFplus) of concentrated feed, respectively, and practicing full grazing (FG), supplementing <100 kg of concentrated feed per cow per year. For three years (2014–2016), data were collected on the farms, and experience and ideas were exchanged and evaluated in a participatory process together with local extension services and researchers. Economic success indicators such as cost price and return to labor from each study group were compared with structurally similar control groups derived from the Swiss Farm Accountancy Data Network after completing an interactive standardization process, which largely balanced farm-specific features in the study groups. Compared with the control groups, the cost price (Swiss francs [CHF] per 100 kg milk) of GBF, GBFplus, and FG was significantly reduced by 20%, 20%, and 26%, respectively. Return to labor (CHF per hour) was significantly higher than in the control group for GBF (20.60 versus. 13.80), GBFplus (19.70 versus. 10.20), and FG (29.30 versus. 19.20). The comparison between the study groups also showed that lower milk revenues due to a lower use of concentrate could be economically compensated by a better input efficiency. A consistent implementation of the production strategy as well as personal qualities in terms of cost management seems to play a decisive role.

KEYWORDS
best practices, concentrate feed, dairy production strategies, profitability

1 | INTRODUCTION

In the course of climate change, the future importance of regions for agricultural production may change significantly (Zabel et al., 2014). With the continuing demand for animal products and the increasing competition for arable land, the attractiveness of grassland could increase in the future (Röös et al., 2017; Schader et al., 2015; Zumwald et al., 2019). The pre-alpine region is characterized by high rainfalls and clay-rich soils, which guarantee optimal conditions for good grass growth. Up to 70% of the forage areas in the pre-alpine regions are permanent grasslands, the yields of which cannot be used for direct human consumption (Coch et al., 2009; Dillon, 2018; Eurostat, 2020). There is a broad consensus to make greater use of these natural resources because they can efficiently

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be converted into human food by ruminants, especially dairy cows (Ertl et al., 2015, 2016; Ertl, Steinwidder, et al., 2016; Steinwidder et al., 2016; Wilkinson, 2011).

Compared with the rest of Europe, dairy farms in the Swiss pre-alpine regions are rather small and have a high degree of heterogeneity with regard to production site and production systems (Hemme, 2019). Expansion of production volumes is hampered by low access to land due to high prices (Gazzarin et al., 2008). In addition, technical measures for increasing intensity as discussed in several studies (Hanrahan et al., 2018; Macdonald et al., 2017) are limited because of environmental restrictions. Several studies address the environmental impact of different milk production systems (Probst et al., 2019; Reidy et al., 2017; Scollan et al., 2017; Zehetmeier et al., 2012). Agricultural policy makers have considered such negative externalities. Particularly in Swiss agricultural policy, farmers are driven to complying with various rules to receive the economically indispensable payments (El Benni & Lehmann, 2010). This compliance concerns especially restrictions on nutrient input via mineral fertilizers and concentrated feed. To achieve a balanced nutrient budget, purchased feed and fertilizers must not exceed the nutrient discharge via products and farmyard manure. Therefore, increase in efficiency is expected not only by increasing product volumes per farm but also from technical or strategic innovation in the grassland management (Dillon, 2018; FAO, 2018).

In the pre-alpine region, most dairy farmers use mixed feeding systems in which grazing during the vegetation period is supplemented or replaced by barn feeding of freshly cut forages. This feed usually consists of a high-quality mixture of selected types of grasses and legumes, which are regularly sown in the crop rotation or grow naturally in permanent grasslands. In contrast to grazing, the cut grasses generally provide better yields because there are less harvest losses. A significant proportion of Swiss dairy farms avoid silage feeding for production of raw milk cheeses.

As the milk yield per cow increased, part-time grazing was increasingly supplemented or replaced by feeding conserved forage such as hay, grass silage, and maize silage. The use of feed mixers for preparing partial or total mixed rations has also increased in recent decades, as in other countries, while the importance of grazing has declined but nowhere disappeared. Barn feeding is supplemented to varying degrees by bought-in concentrated feed. However, the use of concentrated feed for ruminants is strongly criticized in the political discussion in Switzerland. Dairy stakeholders are also aware of the ecological problems with imported soy in particular and are looking for alternatives within the entire value chain (Emmi, 2019; Leiber et al., 2017). The share of concentrate in the ration is already at a low level in Switzerland compared with other countries (Hemme, 2019). This is partly due to the high price, because foreign concentrated feed is charged with tariffs to ensure food security by protecting domestic cereal farmers. This also creates an incentive for dairy farms to focus more on grass-based production systems.

Efficient milk production in distinctly grass-based production systems is no less challenging than in those with high milk yields and high concentrate input. In particular, grass-based systems are much more dependent on natural conditions (weather, climate, topography). High economic performance is possible especially if milk production can be maintained, which places high demands on the management capacities of dairy farmers (Haas & Hofstetter, 2017; Tozer et al., 2003). A major challenge for improving economic efficiency is in management of pasture (Hennessy et al., 2020; Ramsbottom et al., 2015; Wilkinson et al., 2019). In the pre-alpine region, an efficient full grazing strategy cannot be implemented at many production sites due to high fragmentation of the plots or clay-rich soils with unfavorable topographies. In addition, the vegetation period for grazing in the pre-alpine region is limited to between 180 and 220 days per year.

The variety of possible production systems requires a careful decision in order to make optimal use of the natural potential of a production site. However, decision-making on production systems is often based on traditional factors, and the target systems of family farms are not only based on economics (Hansson et al., 2020; Lips et al., 2016). Accordingly, there are only a few farms implementing a clear, economically oriented production strategy for the long term. This is despite the need to lower costs under the given restrictions, especially because the cost difference to other production regions in Europe is considerable and Swiss milk production in particular is dependent on exports (Hemme, 2019).

In this context, little is known—to the best of our knowledge—about the extent to which distinctly grass-based production systems can be economically optimized under different site conditions in the pre-alpine region. We investigated this research question on the basis of real farms that followed a clear, locally adapted strategy over a longer period of time and continuously optimized it according to best practices.

2 | MATERIALS AND METHODS

2.1 | Study area, data, and project design

In the study, we selected 36 dairy farms in three regions, 10 from Eastern, 12 from Western, and 14 from Central Switzerland. The regions are typical for intensive use of natural grassland.

As a first important selection criterion, we previously defined three production strategies according to best practices. A selected farmer was willing to consistently follow one of three production strategies over three years (2014–2016), defined as follows.

In the summer ration, fresh grass had a proportion of at least 2/3 of the total energy intake. Fresh grass could be fed either by grazing or by barn feeding soon after cutting and transport. Accordingly, three feeding systems were distinguished: two mixed systems of part-time grazing with barn feeding of freshly cut forages (mixture of grass, legumes, and herbs) with various input of concentrated feed (GBF and GBFplus) and one pure system with full grazing and block calving in spring (FG). The three systems were differentiated by their use of concentrated feed as following: The target range for the GBF system was between 300 and 500 kg, for GBFplus between 800 and 1,200 kg and for FG <100 kg per cow and year. The quantities of concentrated feed were limited because the optimization of grassland resources had higher priority than a needs-based supply of nutrients—this in knowledge of the high physiological buffer capacity of Swiss dairy cows (Frey et al., 2018; Leiber et al., 2017). Nonetheless, the feeding planning of the observed farms was done in accordance with the animal nutritionist.

The selection procedure, which was carried out via cantonal extension service centers or public calls for applications, resulted in three subgroups, called "study groups," and each representing a production strategy consisting of 11, 13 and 12 farms in the GBF-, GBFplus-, and FG group, respectively. Within one study group, all regions as well as different herd sizes were broadly represented.

The selected sample is characterized by farms that had an above-average level of education and demonstrated a high degree of open-mindedness and motivation to learn in order to improve their practices. We used a participatory approach, as this is particularly effective for the transfer of best practices in research and consultancy (Rogers et al., 2001; Scollan et al., 2017). On average, the farm managers met twice a year in study groups for a mutual exchange of experience and ideas, usually on a farm, moderated by agronomists from the three cantonal extension services, who came from the three regions. After each study group meeting, the results were systematically analyzed and cataloged by the experts within the framework of a self-evaluation regarding the methodological approach and content. Furthermore, the results of the group meetings were analyzed in pre- and post-conference meetings, accompanied by a knowledge transfer scientist and coordinated by the project management. Possible farm-specific improvement potentials were structured according to the individual steps of the implementation of knowledge and innovations (Rogers et al., 2001) and consciously integrated into the knowledge transfer and communication process on the basis of "best practices" (Häller et al., 2018; Heanue et al., 2012; Hennessy & Heanue, 2012). At the end of each year, a review of the research project was conducted with all participants. In addition, at the end of the project, an online survey with validated questions on learning transfer (Ritzmann et al., 2014), on own effectiveness (Schwarzer & Jerusalem, 1999) and on promoting and inhibiting factors in the implementation of the project was conducted among all participants in the study groups.

The three study groups were to be compared with each other, but also with three larger control groups. These consisted of farms in the Swiss Farm Accountancy Data Network (Renner et al., 2019), providing detailed cost data at the production branch level (Lips et al., 2018). On the basis of various criteria, extremes were excluded to ensure that the mean values were not distorted by individual values. A stratified sample was filtered according to dairy farms that were as similar as possible to the study group in terms of size and natural production conditions such as altitude, topography, or orientation toward the sun (production zone). The procedure resulted in consistent and widely representative control groups containing dairy farms between 36 – 41 (GBF), 50 – 60 (GBFplus), and 45 – 50 (FG) cattle livestock units, respectively. The range was determined in such a way that an adequate large group could be included. Technical data such as feeding system or technical equipment were not available for the control groups.

2.2 | Method

For 3 years (2014–2016), a full cost calculation was prepared for each farm based on its accounting data. Under the supervision of the local extension service, the first data processing and the data check for plausibility were carried out jointly. All annual results were averaged over 3 years.

Considering the high heterogeneity of family dairy farms, further data processing was necessary to contribute to a better validity of the main results in order to compare them with those of the larger control group. In the sample of 11–13 farms per group, several farm-specific features, be they financial or infrastructural, had no or only very limited connection to the production strategy but could distort economic results. For this purpose, the farm data were evaluated by a local expert panel comprising the dairy farmers, local extension workers and a dairy researcher using the Typical Farm Approach procedure (Hemme et al., 2014). In a first step, farm-specific features were balanced as far as possible and affected cost items were standardized to isolate the influence of production strategies on economic performance as far as possible. Farm-specific features that were not related to the production strategy included infrastructure (buildings, equipment), capital structure (share and costs of loan capital or interest on liabilities), land improvement, salaries (wage policy), and rent costs (share of rented land and rent price). For the standardization of building, equipment, and interest payments, we applied an uniform method to all farms, while taking into account the farm-specific amounts of inputs and parameters such as number of cows, barn system (loose housing, stanchion barn), feed conservation system, share of grazing, milking system, and share of young livestock. All these elements must again correspond to the labor hours, because these were taken from the original data. The standardized costs were calculated using the Excel-based “Stallpro” calculation model (Gazzarin & Hilty, 2002), which provide the differentiations mentioned above. For the cost of capital, 1.13% was assumed as the average interest rate. This value is based on an initial interest rate of 2% with a depreciation period of 15 years (equipment, machinery)—30 years (buildings) and could be derived from the Excel-function PMT (Payment based on a fixed interest rate and for a fixed duration).

In a second step, the entire set of data was condensed into three farm types representing the three production strategies. For this purpose, we applied the mean values of the standardized farm results within the respective study group. The mean values of the effective milk prices differed only minimally between the groups, with a maximum difference of 0.7 centimes, so that a uniform milk price of 67.6 centimes was used for all three farm types and their control groups.

In a third step, the processed data of these farm types were then entered into the individual farm analysis tool AgriPerform (Gazzarin & Lips, 2018). This Excel-based tool also included the averaged data of the control group, which were filtered internally from the Farm Accountancy Data Network data pool according to the structure of the set-up farm types. In this way, the data of the farm types could be assigned directly to the appropriate control group for the comparison, while joint cost allocation for both groups was based on the same methodology (Lips, 2017; Lips et al., 2018).

The cost price in Swiss francs per kg milk (break-even point) and the return to labor are presented as indicators of economic success factors. The cost price is a long-term indicator of competitiveness and is internationally comparable. Based on a calculated opportunity wage of CHF 28 per hour of labor, the cost price corresponds to full cost coverage. The lower this cost price is the more competitive is the farm. The cost price is calculated using the residual value method (Haberstock, 2005). Here, the expenses (E) were reduced by coupled side revenues from "non-milk" co-products, such as meat and breeding animals (P_{nm}) or social services (direct payments, D) before adding the opportunity costs (O_c, O_l), after which the sum is divided by the amount of milk sold. The resulting cost price (Cp) can then be compared with the milk price (Formula 1).

$$\mathrm{Cp_m} = \frac{E - (D + P_{nm}) + O_c + O_l}{m} \quad (1)$$

$\mathrm{Cp_m}$ = Cost price (CHF per 100 kg milk sold).

E = Expenses (allocated to milk production in CHF).

D = Direct payments (allocated to milk production in CHF).

P_{nm} = Non-milk product revenues (animal sales like sale of calves, heifers, cows).

O_c = Opportunity costs for capital (allocated to milk production in CHF).

O_l = Opportunity costs for labor (allocated to milk production in CHF).

m = milk sold per year in kg.

Return to labor is an income indicator measuring labor efficiency within the production system. All costs except labor costs were deducted from the total revenues and put in relation to the labor hours used, resulting in the actual hourly wage (Formula 2).

$$R_{lh} = \frac{P_{tot} + D - (E_{tot} - E_e) - (O_{tot} - O_l)}{\mathrm{lh}} \quad (2)$$

R_{lh} = Return to labor (CHF per labor hour).

P_{tot} = Total product revenues (milk and non-milk returns).

D = Direct payments (allocated to milk production in CHF).

E_{tot} = Expenses (allocated to milk production in CHF).

E_e = Expenses for employees (allocated to milk production in CHF).

O_{tot} = Total opportunity costs (allocated to milk production in CHF).

O_l = Opportunity costs for labor (allocated to milk production in CHF).

lh = labor hours per year (allocated to the milk production branch).

Significant differences in economic performance between the groups were tested by applying a Wilcoxon rank-sum test using the STATA statistical program. Correlations between individual key variables were captured with the Pearson correlation coefficient.

3 | RESULTS

Table 1 shows some details of the production systems of the study groups for each production strategy. The production strategy of GBF and FG is characterized by the minimization of input (costs), while that of GBFplus is aimed at maximizing milk revenues, which is mainly reflected in the average milk yield per cow per year (6,762, 8,140, and 5,618 kg), the average use of concentrated feed (430, 1,160, and 90 kg) and average herd size (36, 50, and 40 cows) for GBF, GBFplus, and FG, respectively.

The standard deviation was considerable. Accordingly, the production volume varied in ranges of 112–487 tons (GBF), 200–839 tons (GBFplus), and 139–337 tons (FG). The production volume of GBF was slightly lower than that of the control group due to lower milk yield. In contrast, GBFplus produced more milk due to higher milk yield per cow and slightly higher herd size compared with its control group. FG in turn had an almost identical herd size, but produced much less milk because the milk yield per cow was much lower compared to the control group. The differences in these technical data already indicate that the production strategies of the study groups differ from the more common practices.

The lower part of Table 1 shows the extent to which the standardization process adjusted the costs of single farms in order to largely eliminate the special features of the farm and thus achieve a more general type of farm. In the case of infrastructure costs, a considerable upward adjustment had to be made for groups GBFplus and especially FG. The farms in these groups thus had very favorable infrastructure costs compared with the usual average. Similarly, upward adjustments had to be made to employee costs for the two GBF groups, suggesting that they often worked with relatively cheap labor (e.g., apprentices). In total, the upward adjustments for GBF, GBFplus, and FG amounted to 6%, 14%, and 21%, respectively.

The scatter plot of Figure 1 shows return to labor as economic performance indicator for the standardized single farms in relation to milk yield. Heterogeneity within the study groups was high in terms of both variables, but the groups were more or less well aligned on the X-axis according to the milk yield level. There is obviously no direct connection between milk yield on single farms and their economic performance. As shown in Table 2, there was no significant correlation between size variables (herd size, milk yield, and production volume) and economic performance variables (cost price, return to labor).

Table 3 shows the economic results for the three farm types representing the study groups in comparison with the respective control group. GBF and GBFplus produced milk about 20% cheaper than the control group (cost price 76.4 versus 95.7 and 73.4 versus 92.1, respectively). The cost price in FG was 26% lower than that in the control group and was below the milk price meaning that this farm type made profit (61.8 versus 83.5; milk price 67.6). Return to labor

TABLE 1 Farm characteristics of the study groups compared with the control groups and impact of the standardization process for infrastructure[a] and employee costs calculated in CHF (mean values, *SD* in brackets)

Milk production systems in 2014–2016	Unit	GBF	Control	GBFplus	Control	FG	Control
Farms	number	11	68	13	68	12	69
Herd size	number of cows	35.6 (15.4)	33.8 (3.3)	49.7 (18.2)	47.4 (5.8)	40.8 (14.6)	40.4 (3.5)
Production volume, sold	tons per year, per farm	225 (104)	236 (49)	389 (182)	351 (74)	207 (169)	273 (51)
Milk yield	kg per year, per cow	6,762 (517)	7,325 (1,369)	8,140 (902)	7,664 (1,143)	5,618 (1,009)	7,156 (1,010)
Concentrate input	kg per year, per cow	430 (181)	N/A	1,160 (456)	N/A	90 (126)	N/A
Stocking rate[b]	cLU per ha	1.9 (0.3)	N/A	2.2 (0.7)	N/A	1.7 (0.3)	N/A
Infrastructure (real)	CHF per year	43,450		55,792		40,488	
Infrastructure (stand.)	CHF per year	44,092		65,322		52,529	
Employee costs (real)	CHF per year	16,526		26,989		15,741	
Employee costs (stand.)	CHF per year	19,387		29,391		15,715	
Total cost adjustment	%	+6		+14%		+21%	

Abbreviations: CHF, Swiss francs; GBF, part-time grazing and barn feeding of freshly cut forages; FG, full grazing; N/A, not available.
[a]Costs for buildings, equipment, interest rates, land improvement, land rents.
[b]Cattle Livestock units (cLU) per hectare forage area.

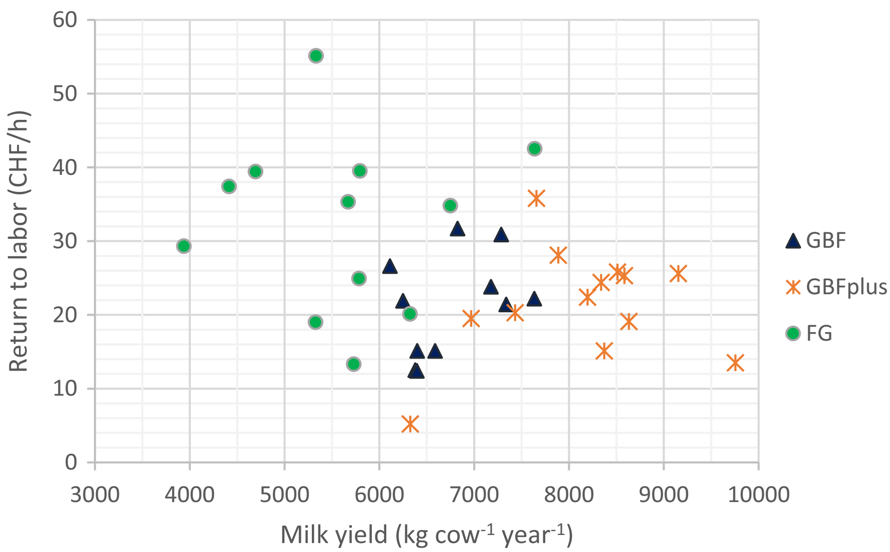

FIGURE 1 Return to labor and milk yield of single farms, indicating low importance of milk yield for economic performance (GBF, part-time grazing and barn feeding of freshly cut grass; FG, full grazing)

TABLE 2 Relationship between size and economic performance in the study groups; Correlation coefficients (Pearson, *5% significance level)

	Herd size (cows)	Milk yield	Production volume	Cost price	Return to labor
Herd size	1.00				
Milk yield	0.26	1.00			
Production volume	0.88*	0.65*	1.00		
Cost price	−0.30	0.06	−0.21	1.00	
Return to labor	0.23	−0.17	0.1	−0.88*	1.00

in the farm types GBF, GBFplus, and FG was calculated to 20.60, 19.70, and 29.30 CHF, corresponding to higher returns than in the control group of +49%, +93%, and +53%, respectively.

Differences in return to labor of FG to GBFplus (p = .03) were significant (Table 4) and nearly also to GBF (p = .11). For the other economic indicator "cost price," differences of FG to both other

TABLE 3 Differences in cost price (break-even point) and return to labor between standardized study groups (farm types) and control groups (values per year)

Economic indicator	Unit	GBF	Control	GBFplus	Control	FG	Control
Herd size	number of cows	36	34	50	47	41	40
Milk yield	kg per cow	6,818	7,325	8,228	7,664	5,518	7,156
Milk production sold	tons	224.69	235.77	389.28	351.07	207.00	272.98
Labor	hours	3,892	4,550	4,451	4,760	3,536	4,803
Milk receipts	CHF 100 per kg	67.6	67.6	67.6	67.6	67.6	67.6
Non-milk returns[a]	CHF 100 per kg	40.7	38.1	28.1	29.8	58.9	42.3
Dairy expenses	CHF 100 per kg	80.1	90.0	80.1	91.2	82.8	85.9
Concentrate costs	CHF 100 per kg	6.8	12.1	12.9	14.6	3.0	10.4
Opportunity costs	CHF 100 per kg	36.9	43.8	21.4	30.7	37.9	39.9
Labor costs[b]	CHF 100 per kg	44.3	54.8	28.4	38.5	44.2	49.9
Cost price	CHF 100 per kg	76.3	95.7	73.4	92.1	61.8	83.5
Difference		−20%		−20%		−26%	
Return to labor	CHF per hr	20.6	13.8	19.7	10.2	29.3	19.2
Difference		+49%		+93%		+53%	

Abbreviations: CHF, Swiss francs; FG, full grazing; GBF, part-time grazing and barn feeding of freshly cut grass.

[a]Calves, heifers, cows, direct payments.

[b]Employee costs and opportunity costs for family labor.

TABLE 4 Significance of differences in economic performance between study groups: probabilities of Wilcoxon rank-sum test

Comparison	Cost price	Return to labor
GBF to GBFplus	0.50	0.84
GBF to FG	0.03	0.11
GBFplus to FG	0.06	0.03

Abbreviations: FG, full grazing;GBF, part-time grazing and barn feeding of freshly cut grass.

groups GBF and GBFplus were significant (p = .03 and p = .06, respectively). Differences between the two GBF groups were not significant in both economic indicators (Table 4).

Figure 2 shows the differences in the individual cost positions between the study group and the control group. Considerable differences were recorded in the cost of concentrate, although these differences were largely compensated by other direct cost items, with the result that overall direct costs differed only slightly. More substantial differences were found in building costs and labor costs. The costs of buildings and equipment for the three farm types GBF, GBFplus, and FG were 26%, 36%, and 20%, respectively, lower than those in the control group although these costs had already been adjusted upwards as part of the standardization process. A similar picture resulted for labor costs such as employee costs and own labor (opportunity costs): Here, too, the costs in each farm type were considerably lower compared with the control group and were reduced by 25%, 31%, and 19% in GBF, GBFplus, and FG, respectively. The costs for machinery were also lower, albeit to a lesser extent at 6%, 12%, and 18%, respectively.

4 | DISCUSSION

In a participatory research and extension service project, data were collected over three years from 36 farms in three groups, each representing three distinctly grass-based production strategies, with the single farm data in each group being standardized into three farm types. The results on economic success factors can be interpreted on two levels: The first level shows the differences within the study groups between production strategies, while the second level shows the differences between the study groups and a more representative control group with similar herd size.

The differences in cost price and return to labor between the two GBF production strategies were relatively small, although production volume differed significantly in terms of herd size and milk yield per cow. The clearly higher milk yield of GBFplus is also due to the considerably higher use of concentrated feed. While in the GBF and FG groups, the use of concentrated feed was clearly below the Swiss average, it was slightly higher for GBFplus group (Reidy & Ineichen, 2015). This means that the low absolute cost in the case of GBF led to the same results as the significantly higher milk receipts in the case of GBFplus, which, however, has to be acquired at great expense. There was a greater difference between the two GBF groups and the FG group, which performed considerably better both in terms of cost price and return to labor, although this group had the lowest production volume with a significantly lower milk yield and much lower concentrate input. The latter result is in line with previous studies, which consistently found the full grazing strategy to have great economic advantages (Gazzarin et al., 2011; Haas & Hofstetter, 2017; Hemme et al., 2014; Hofstetter et al., 2014). Further remarkable is the good performance of the control group of

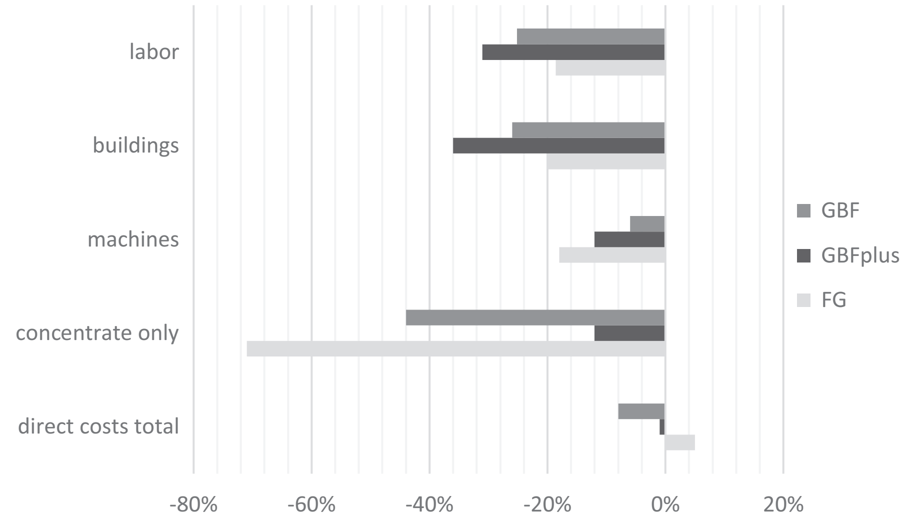

FIGURE 2 Differences in the cost elements between each study group and its control group (GBF, part-time grazing and barn feeding of freshly cut grass; FG, full grazing)

FG, although it had the lowest milk yield compared with the other control groups. As in FG, the good result was mainly due to the high coupled side revenues from milk production (meat, breeding, direct payments), which indicates that diversification within milk production makes economic sense.

Thus, the economic results achieved with low levels of concentrated feed were similar or even better. This is relevant in the current discussion about the competition on arable land between human food and animal feed, which is increasingly seen as critical in terms of energy efficiency and environmental impact in the course of a growing world population (Röös et al., 2017; Schader et al., 2015).

The second comparison of the economic success factors was carried out between the study farms and the larger control groups in order to estimate the economic effect of the production strategies implemented and optimized according to best practices compared with the control groups implementing more average production practices. The better results in both economic success factors are remarkable for all farm types. These strategies were able to produce milk between 20% (GBF, GBFplus) and 26% (FG) cheaper. Our statements are limited in that we do not know exactly about the feeding system of the control group. The labor input of the control group could also be verified in less detail and therefore represents a less accurate estimate than in the Study group. However, we can expect that the control groups also practised largely grass-based feeding, but in a less focused way and on average with a higher proportion of conserved feed (including silage) in the summer ration. Considering the differences in concentrate costs, at least the control groups of GBF and FG are likely to have used much higher amounts of concentrated feed. In any case, various studies also confirm that a high proportion of grass and pasture in the ration with moderate concentrated feed can reduce feed and labor costs (Dillon et al., 2005; Hanrahan et al., 2018; Peyraud et al., 2010).

Despite a careful standardization process of the single farm data, the major differences of the farm types to their respective control group were in the structural cost positions of labor, buildings, and machinery, which indicates that the farms had already exhibited strong cost management before the project started. The pure fact that the farmers had voluntarily agreed to participate in this project in order to learn for themselves reflects a certain personal qualification. Consequently, among 12 reasons for participating in the project, the participants of the study group mentioned the reason "I want to improve the profitability of my farm" most frequently in the final survey.

The lack of correlation between the level of production volume and the economic success factors in the study groups suggests that the implementation of a clear grass-based feeding strategy, coupled with personal qualification, is crucial to the economic performance. In fact, the dairy farmer's management capacity is an important factor in explaining differences in economic performance (Hansen & Greve, 2015). According to Hansson (2008), managerial capacities primarily influence input efficiency such as costs of production, which is in line with our findings. Positive profitability attitudes and perceptions and participation in study circles will be considered particularly relevant, as well as locus of control, which indicates farmers' perceived ability to influence what happens (Hansson, 2008). Accordingly, a survey of the participants on their self-assessment at the end of the project revealed very high values for their own effectiveness and the perceived benefit of the project in terms of knowledge gain (average rating of 4, on a scale from 1 “not correct at all” to 5 “completely correct”). So, if farmers themselves believe that they can change the economic situation, this may be another explanation for the remarkable extent of the economic differences (Daft, 2003; Hansson, 2008).

5 | CONCLUSIONS

Following grass-based strategies with low concentrated feed in the pre-alpine region can greatly reduce cost price and increase labor income. However, farm managers must have the will to define the appropriate production strategy at each production site and to implement it consistently. This in turn seems to require certain personal qualifications in management capacities that can at least compensate for lower production volumes and/or lower milk yields due to lower concentrated feed intensity. As long as the natural conditions are there, the full grazing system with appropriate pasture management must have priority from an economic point of view as well as from a sustainability perspective.

The setting up of study groups together with all stakeholders (farm managers including family, researchers, and agricultural extension service) might be an important measure to facilitate practical management decisions and innovation and to support the transfer of knowledge with specific measures. The influence of managerial capabilities on the economic performance is to be filtered out in specific studies so that these competencies can be implemented increased in education and extension services.

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ORCID

Christian Gazzarin https://orcid.org/0000-0002-1492-703X

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