Grassland-based beef production: a case study on the economic impact and ecosystem services in a Limousin cattle farm

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Abstract

This case study assessed the economic impact of grassland-based beef production and associated ecosystem services in a commercial Limousin cattle farm. It aimed to determine (1) the technical and economic performances of different fodder crops including permanent and temporary grasslands, (2) how grazed grass and self-produced fodders are utilised by young bulls and heifers, and (3) associated ecosystem services including carbon fixation of permanent grassland soils and beef meat quality produced from grass. Data were collected from 2013 to 2015. Dry matter yield, nutritional value and cost price were determined for each fodder crop. Animals were weighed every three weeks. In 2015, meat samples from seven bulls finished on pasture were analysed for fatty acids composition. Average daily gains ranged from 1.29 kg day^{-1} in 2015 to 1.35 in 2014 for young bulls grown on grazed grass without supplementation. Grassland soil carbon content linearly increased with grassland age. The meat polyunsaturated fatty acids content increased with grazing duration. In conclusion, this study showed that grassland allows an increase in both the economic and environmental sustainability of beef production systems but also offers nutritional health benefits to the consumer.

Keywords: grassland, grazing, meat production, feed autonomy, carbon fixation, PUFA

Introduction

During the last decades, an increasing number of farmers have actively developed the feed autonomy of their farms (Lucas *et al*., 2016). This relies, in particular, on high grassland production, including grazed pastures and other fodder. The economic impact of a grassland-based beef production and associated ecosystem services (ES) were assessed in a commercial Limousin cattle farm. Three questions were addressed based on the challenges of the farm:

1. To determine the technical and economic performances of on-farm produced fodders.
2. To explore how cattle utilise the on-farm produced fodders. Two cases were studied: (1) growing and finishing young bulls on grazed grass during the grazing season, and (2) growing young bulls and heifers with on-farm produced rations during winter.
3. To investigate ES associated with a grassland-based beef production. Two aspects were considered: (2) carbon fixation in permanent grassland soils, and (2) beef meat quality produced on grass in terms of fatty acid composition.

Materials and methods

This case study was conducted from 2013 to 2015 in the Ferme Saint-Michel, located in the loamy region of Belgium, province of Hainaut (Faux, 2016). In 2015, the farm was in conversion to organic agriculture. The dry matter (DM) yield and nutritional value (Van Es, 1975; Tamminga *et al*., 1994) of each fodder crop were determined: maize (*Zea mays* L.) (2013), immature rye (*Secale cereale* L.)-Italian ryegrass (*Lolium multiflorum* Lam.) mixture (2014), immature cereals-protein crops mixture (2015), alfalfa (*Medicago sativa* L.)-dactyl (*Dactylis glomerata* L.) mixture (2013-14-15), permanent grasslands (2013-14), and protein pea (*Pisum sativum* L.) (2013-14-15). Cost price of each crop was computed based on operational and structural costs divided by crop DM production. The economic margin was obtained by subtracting the total costs from the economic value, estimated based on the crop nutritional value and the relationship between market price and nutritional value of feeds taken as references.

The performances of young bulls grown on grazed grass before being finished indoors in 2013 or on grazed grass with supplementation (2014-15), were recorded. The winter growth of young bulls and heifers was monitored. Animals were weighed every three weeks. The cost price and level of feed autonomy of each ration was computed.

Ecosystem services were assessed as follows: the soil carbon (C) content was determined in nine grassland plots of age ranging from 1 to 29 years. The impact of grazed grass consumption on meat quality in terms of fatty acid composition was assessed in 2015 by analysing meat samples from seven bulls slaughtered after distinct grazing durations.

Results and discussion

The highest DM yields were obtained with maize, the largest economic margin was achieved with the grazed pasture and alfalfa-dactylis mixture. This was explained by the high crude protein content of these fodders and the high protein economic value. It emphasized potential profit that can be achieved by producing protein-rich fodders.

Average daily gains (ADG), ranging from 1.29 to 1.35 kg day^{-1}, were obtained with young bulls grown on grazed grass during spring without supplementation. Such ADG were associated with low ration cost prices (Table 1, Case study 1A).

Table 1. Animal performances, cost price and feed autonomy levels obtained with rations dedicated to young Limousin cattle during the grazing season (Case study - 1) and during winter (Case study - 2).

Year	Trial period	No. of animals	Ration[1]	Age at start (month)	ADG[2] kg day^{-1}	Ration cost € kg^{-1} DM	Ration cost € day^{-1}	Ration cost € kg^{-1} weight gain	Feed autonomy level (%)
Case study 1									
A. Growing young bulls at pasture									
2013	30/04 - 6/07	8	Grazed grass	13	1.32	0.11	1.05	0.79	100
2014	26/04-30/08	7		11,8	1.35	0.11	1.05	0.77	100
2015	2/05-12/09	8		13.5	1.29	0.1	0.95	0.74	100
B. Finishing young bulls indoors									
2013	3/08-20/10	3	SBpulp+Trit+PP+CC	17.3	1.53	0.25	2.49	1.63	91 to 33
C. Finishing young bulls at pasture									
2014	1/06-30/09	4	Grazed grass+SBpulp+Trit	16.3	1.62	0.14	1.44	0.89	100 to 76
2015	1/06-31/08	3	Grazed grass+Trit+orgCC	17	1.45	0.19	1.93	1.33	77
Case study 2									
A. Winter rations for young bulls									
2013	4/10-26/12	8	Maize+Alf-Dact+ Trit+PP+CC	15	1.39	0.14	1.46	1.05	93
2014	1/01-11/03	8	Maize+SBpulp+Trit+CC	9.1	1.25	0.16	1.35	1.08	84 to 63
2015	20/01-8/04	11	Rye-IRG+PP+Trit+orgCC	10.8	1.29	0.18	1.5	1.16	94
2016	29/01-29/03	8	ICP+Trit+Barl+orgCC	10.9	1.38	0.21	1.78	1.29	96
B. Winter rations for 1-year old heifers									
2014	1/01-11/03	5	Maize+SBpulp+Alf-Dact	8.6	0.84	0.11	0.73	0.87	100 to 86
2016	29/01-29/03	7	ICP+Alf-Dact+Cereals	10.5	1.08	0.12	0.81	0.75	100
C. Winter rations for 2-years old heifers									
2016	29/01-29/03	8	ICP+Alf-Dact	21.9	0.82	0.09	0.85	1.04	100

[1] Alf-Dact = alfalfa-dactyl mixture, Barl = winter barley, CC = concentrate, orgCC = organic concentrate, ICP = immature cereal-legume mixture, PP = protein pea, Rye-IRG = rye-italian ryegrass mixture, SBpulp = sugarbeet pressed pulp, Trit = triticale. The composition of rations is fully described in Faux (2016).

[2] ADG stands for average daily gain.

Finishing young bulls on grazed grass with supplementation offered (Case study 1C) rather than indoors (Case study 1B), reduced the ration cost price while providing comparable ADG. A live weight of 703 kg and a carcass weight of 471 kg were obtained at 19 months, slaughtering age, with bulls finished at pasture on average over 2014 and 2015. For winter rations, the inclusion of a protein-rich fodder like the alfalfa-dactylis mixture provided satisfactory ADG and resulted in relatively low ration cost prices (Case study 2).

In terms of ES, the soil C content linearly increased with grassland age (Figure 1.1). This could be explained by the accumulation of root biomass and raises the question of the potential of long-term C sequestration in grassland soils (Acharya *et al*., 2012). An increased content in polyunsaturated fatty acids (PUFAs) in beef meat with grazing duration was observed (Figure 1.2), which suggests that the feeding strategy (i.e. growing bulls on grass as much as possible) positively affects meat quality and is in agreement with Duru *et al*. (2017).

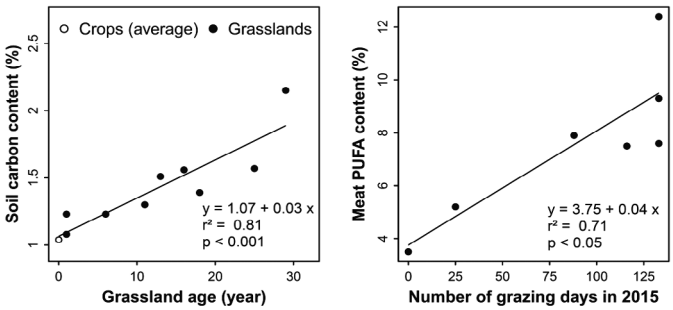

Figure 1. Ecosystem services associated with grass-based beef production. (1) Soil C content in grasslands of distinct ages; (2) PUFA content in meat from Limousin bulls slaughtered after distinct grazing durations.

Conclusion

This study analysed the economic impact and associated ES of a beef cattle production system based on grazed grass and self-produced fodder. Results suggest that using grassland effectively increases both the economic and environmental sustainability of beef production systems and offers the consumer a product with nutritional benefits.

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