Economic impacts of integration of a biogas plant in a stockless organic farming system

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***Abstract* - Organic farmers were amongst the pioneers of the biogas production: Energy self-sufficiency and closed nutrient cycles were primary reasons for a biogas plant. Today a significant number of organic farms are stockless. On a stockless organic farm a biogas plant can partially fulfil functions of livestock production, especially the supply of mobile manure. In this paper, results from the systemic field trial Viehhausen are used together with calculation data to analyse the economic impacts of integrating different biogas plants in stockless organic farming systems. The economic indicator is the entrepreneurial profit of the overall farm including the economic results of the biogas plant. The results show that a biogas plant can improve the economic situation of a stockless farming system, even if the biogas plant does not operate profitably. Manuring with digestate has significantly raised the yields of the cash crops in the field trial. Sustainable organic biogas production can stabilize food production and energy supply. Thus it can improve the economic efficiency of organic farms in general.**

INTRODUCTION

Originally organic farming systems have followed the ideal of a mixed farm striving for closed nutrient cycles. Since the nineteen-eighties the importance of stockless crop production, however, has increased for organic farming. Through the specialization of an organic mixed farming system to a stockless one the typical uses for legume field forage cease and manure is omitted. A biogas plant can partially fulfil functions of livestock production, especially the supply of mobile manure. The specific manuring with digestate to non-legume crops can increase the yields and enhance the quality of the agriculture products (e.g. Reents et al. 2011). Keeping in mind a rising demand for organically produced food, an increasing competition between food and energy production and the requirement for a "sustainable intensification" of agriculture the integration of a biogas plant into a stockless farming system seems to be advantageous. But there are also voices against biogas production: e.g. negative impacts on crop rotation and soil fertility, usage of conventional substrates. Lower yield levels and higher land usage compared to conventional agriculture are often mentioned (Ponisio et al., 2015). Also the economic profitability of biogas production in Germany has become more difficult with falling feed-in tariffs of the German Renewable Energy Act (EEG 2014).

For the economic analysis of an organic biogas plant the overall farm outcome (biogas plant and arable farming) must be considered because of various internal system effects. In research this holistic analysis approach has seldomly been considered. Blumenstein et al. (2015) calculated with this holistic analysis approach. But the results were based solely on theoretical yield functions. This paper combines an economic analysis on the basis of the results of the systemic field trial Viehhausen with an integral holistic approach on the basis of calculation data. The objective is to show whether biogas production in combination with organic farming makes economically sense or not.

METHODS

The systemic field trial Viehhausen has been created in August 2009 at the experimental station Viehhausen (Bavaria / Germany). We analyse in this paper two of the farming systems of the field trial: The reference farming system is the "cash crop system" with the following crop rotation: grass-legume mixture (GLM), winter wheat (Triticum aestivum L.), winter triticale (×Triticosecale), faba bean (Vicia faba) and winter rye (Secale cereale L.). The GLM is mulched in this system and remains as organic fertilizer on the field. The "biogas system" has the same crop rotation as the "cash crop system". In contrast to the "cash crop system", the GLM is harvested as biogas substrate. The digestate is selectively applied to the non-legume cash crops of this system. Every crop rotation is cultivated in four repetitions. Under the experimental conditions the "biogas system" shows significantly higher dry matter yields compared to the "cash crop system". Brynzinski and Hülsbergen (2015) justify the increased yields with the specific fertilization with digestate.

We assume that the analysed model farms follow the Council Regulation (EC) No. 834/2007. Each model farm has 50 ha arable land. On the basis of the trial entries and calculation data (KTBL, 2014b) practical field working steps including the supplies (i.e. seed) are defined. Average Bavarian market prices (LfL, 2014) are assumed for the cash crops.

For the biogas systems we analyse three different biogas plants (table 1). The technical parameters and investments for the biogas plants are derived from calculation data (KTBL, 2014a). We determine

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for the basis variant that at least 80% of the methane must stem from the self-produced GLM. Therefore we assume that four identical model farms (each 50 ha arable land) operate the biogas plants in a co-operation: The farms equally divide the expenses and revenues, supply the GLM as biogas substrate and pick up the digestate. For a year-round capacity utilization of 91% co-substrates must be bought: In the basis variant conventional corn silage and stable manure are bought in addition. For the variants 2 and 3 it is assumed that the substrates of the basic variant are supplemented by liquid manure. The digestive coming out from the liquid manure is dispended for free. The costs of corn silage are market prices (LFL, 2014). For stable and liquid manure only the costs for the transport accrue. The biogas plant uses its own energy (heat and electricity) to cover its own energy demand. For the net electricity the feed-in tariff of the German Renewable Energy Act (EEG, 2014) are applied. We assume that half of the produced heat is sold. The heating revenues are calculated with 20 €MWh_{th}^{-1}.

Table 1. Definition of the biogas plants.

variants	electrical power in kW	net electricity production in MWh_{el}	electricity revenues in cents kWh^{-1}
basis	75	534	13.66
1	150	1,068	10.29
2	300	2,136	9.83

For the economic analysis we use the entrepreneurial profit of the overall farm in € ha^{-1} (arable land). By taking the full costs, the implicit costs (capital, work, land) and the total farm income into consideration long-term analysis and the comparison of different farming systems is possible. The entrepreneurial profits are determined for all repetitions (n=4) of the field trial and shown as arithmetic means for each crop year with standard deviations.

RESULTS

Figure 1 shows the entrepreneurial profits of the cash crop system and of the three variants of the biogas system.

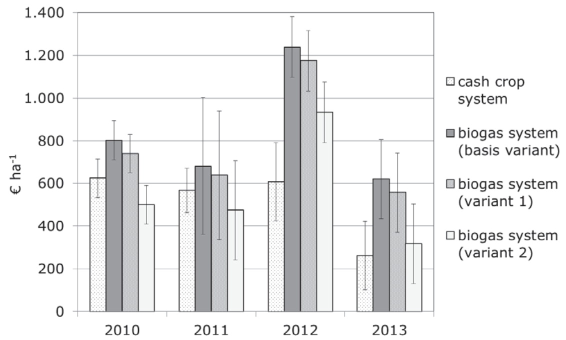

Figure 1. Annual entrepreneurial profits of the overall farm in € ha^{-1} (arithmetic means, n=4).

Under the conditions of the field trial the annual entrepreneurial profits of the biogas system basis variant (621 to 1,238 € ha^{-1}) are higher compared to the cash crop system (262 to 624 € ha^{-1}). The same is true for the biogas system variant 1. Depending on the crop year the biogas system variant 2 shows economic advantages or disadvantages compared to the sole cash crop system.

DISCUSSION

The objective of this paper is to answer the question whether biogas production along with organic farming is profitable. It is concluded in this study that biogas systems can enhance overall farm profitability compared to the cash crop system. The economic advantages of the biogas system are the result of increased cash crop yields due to the manuring with digestate. The higher the cash crop yields the higher the revenues. This confirms the results of Blumenstein et al. (2015). The quality improvement through specific manuring of digestate shown by Reents et al. (2011) can increase the market performance even more. The economic results of the different biogas systems show that the dimensioning of the biogas plant is important for an improvement of the overall economic outcome of the farm. As long as the additional revenues of the cash crops are higher than possible financial losses of a biogas plant the size of the particular biogas plant makes good economic sense. The economic losses of the biogas plant of variant 2, however, cannot be compensated by the additional revenues of the cash crops in 2010 and 2011. Consequently the size of the biogas plant must match with the quantity of the own substrates, the acquisition of the co-substrates (price, distance) and especially the need for digestate.

A sustainable organic biogas production could stabilize food and energy supply and improve the economic efficiency of organic farms in general. Simultaneously this could be an opportunity for the biogas sector itself for the future development.

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