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Biogas in Organic Agriculture: Utopia, Dead-End or Role Model? – A Synopsis

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Abstract

Present-day organic biogas production provokes controversy of its role between the poles of societal demands, principles of organic agriculture and economic constraints. By integrating multiple arguments on organic biogas in a meta-level, several future trends are identified. However, only one option seems reasonable, where anaerobic digestion on a confined scale, mainly based on residual substrate input, serves both energy and food security demands while enhancing the productivity of organic farming systems.

Introduction

Aiming to implement the concept of energy self-sufficiency organic farming operations were amongst the first to develop adapted biogas systems (anaerobic digestion, AD) (Anspach *et al.* 2010). Regarding *e.g.* Central Europe, a general biogas boom resulted from the institutional stimulation towards an increased supply with renewable energy, involving massive financial promotion. Likewise an expansion of organic biogas generation with dramatically changing structures towards larger-scaled biogas plants was induced. This process triggered a controversial discussion on both the present and future role of biogas production in organic agriculture (OA). Arguments touch on the fundamental principles and self-conception of OA, *e.g.* the production of food *vs.* bioenergy commodities (Braun-Keller 2012), adressing the problem of regional land use competition as well as indirect land use changes (ILUC) on a global scale (FAO 2010). Another example is the idea of a preferably closed farming cycle, while increasingly externally purchased conventional co-subtrates are applied in organic biogas production (Siegmeier *et al.* 2011). Among other points the effects on humus reproduction and soil life (*e.g.* Möller 2009) are discussed. This paper systematically elicits for different settings, if AD actually contradicts the core ideas of OA, or, on the contrary, might be a valuable component of progressive organic farming systems. Trade-offs of OA objectives and thresholds between sense and nonsense of organic biogas systems are discussed.

Material and methods

On a meta-level, organic biogas production is systematically integrated in the area of conflicts between OA principles, societal demands and economic constraints, in order to establish an evaluation framework to assess the future role of anaerobic digestion in OA. As basis for the framework setup an overview of the diverse aspects of biogas production in OA including arguments and statements from multiple stakeholders (relevant literature, experts, growers associations, scientists) is provided.

Results and Discussion

In the beginnings of anaerobic digestion in OA small-scaled biogas plants fed with animal excreta and herbal residues particularly served the purpose of energy self-sufficiency, and therefore envisioned the organic principle of a preferably closed farming cycle. With increased subsidization of biogas production and subsequent growing plant sizes numerous controversial arguments emerged relating to fundamental organic principles as well as agronomic and ethical concerns. These parameters of controversy, as discussed below, can be associated to three major levels of challenges as part of an evaluation framework for organic biogas production, i.e. i.) society´s demands on sustainable energy and food production, ii.) compatibility with the principles of OA and iii.) production economic potentials and constraints on the farm level (Fig. 1).

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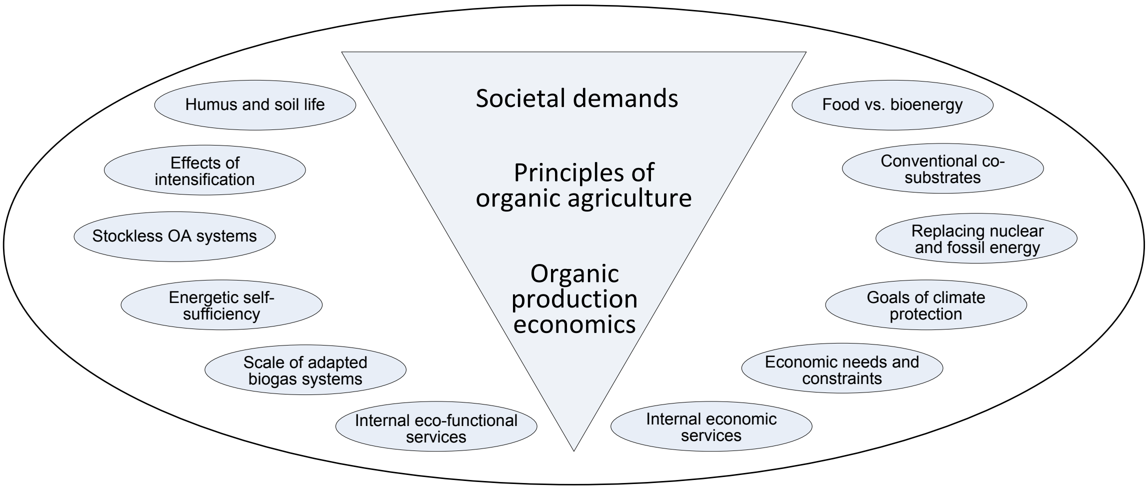

Fig. 1: Levels of challenges (within triangle) and associated parameters of controversy of organic biogas production

One crucial parameter, touching upon all three identified levels, is the **increased use of conventional co-substrates in organic biogas production**. Indeed, by now more than half of the analyzed organic biogas plants in Germany use conventionally produced co-substrates, and 80 % of the installed electrical performance (kW_{el}) is produced with the help of conventional co-substrates (Siegmeier *et al.* 2011). Reasons for this trend can be seen in i.) bad planning of biogas plants too large for the exclusive use of internal substrates or even ii.) deliberate planning to enhance methane and economic yields by using low-cost substrates. Concerning the levels of OA principles and societal response, the intensified use of conventional substrates contradicts the organic idea of a preferably closed farm cycle, negatively influences customer perception concerning organic biogas production and threatens credibility of organic agriculture in general. In summary, the exclusive focus on economic advantages with the tendency of conventionalization of organic biogas production does not seem a viable future option.

One of the most discussed arguments concerning biogas in OA is the **precendence of food vs. energy production**. Here, society´s needs to saturate its rising hunger for energy through increased proportions of renewable biomass resources contradicts the rising need for food and the principles of OA with its focus on food production. Even though organic farming enterprises so far are faced only locally with the competition for agricultural land with (conventional) biogas plants, if political circumstances furthermore heavily promote biogas production, a strong competition between land for organically produced food and bioenergy substrates will prevail. This will lead to a replacement of organically managed cropland, since maximum payable rents for most organic farming systems are estimated below conventional substrate production systems (Meyer & Priefer 2012). In order to promote both organic farming and biogas generation and avoid trade-offs, one of the most crucial preconditions is the increased exhaustion of residual materials for biogas generation, which does not contradict but even sensibly complements food production.

Other concerns particularly relating to the level of OA principles refer *e.g.* to the **degradation of carbon compounds** during fermentation and subsequent methane (CH_4) generation, since it is feared to have **negative effects on soil humus cycles** and supply. In terms of production economics this may require efforts to keep a stable humus balance. In addition, the composition of biogas digestates with a higher ammonium ratio of the nitrogen (N) fraction compared to unfermented slurry is suspected to have negative effects on soil life, in particular earth worm populations. Literature review on these topics is heterogeneous and does not allow for a definite positive or negative evaluation. Results show a tendency, however, that soil humus supply under a biogas slurry fertilizing regime can be sufficient to sustain or even enhance soil humus supply in the long run (*e.g.* Möller 2009). Furthermore, although biogas digestate fertilization can alter the distribution of earthworm species, it is unlikely to negatively affect the total earthworm population (Dominguez 2012). Another argument implies the fear that the higher content of ammonia in the biogas digestates has negative effects on plant health due to its characteristics which are more similar to mineral fertilizers used in conventional agriculture, contradicting OA principles. Looked at from another perspective, however, the **integration of biogas** generation with an intelligent use of biogas digestates **can** (in both stock-keeping and especially stockless organic farming systems) **contribute to the goal of an *eco-functional intensification* of organic agriculture** (Niggli *et al.* 2008). In times of increasingly scarce resources, an integrated biogas approach can achieve both a secured (organic) food supply and a secured provision of ecosystem services by a more efficient nutrient management and therefore sustained or even enhanced productivity (Stinner *et al.* 2008, Möller *et al.* 2008). Performance enhancing systematic effects particularly comprise improved nutrient efficiency through a better spatiotemporal allocation accompanied by an enhanced nitrogen (N) availability of biogas digestates. This can lead to increased yields and product quality (grain protein content) as well as changes in crop rotation towards more N-affine crops, resulting in a better market performance of the whole crop rotation. Instead of mulching herbal residues (*e.g.* in stockless systems) their bioenergetic use increases value-added as well as N_2 fixation of legumes by up to 20 % and supports climate protection goals through reduced N_2O emissions (Stinner *et al.* 2008). Potential phytosanitary effects through weed seed reduction during fermentation or enhanced plant health through more diversified crop rotations are harder to quantify but possible outcomes. Biogas produced on organic substrates so far does not realize a premium organic market prize. Rather than being contradictory to OA principles and society´s needs for food, the integration of biogas in organic farms can therefore help to restore economic sustainability of the whole farming system through an enhanced productivity of food production.

Conclusions

Assessing the above established evaluation framework, conclusions on the future role of organic biogas production are drawn as follows. Even though appropriately integrated organic biogas production can be a reasonable option for organic farming systems, the scarcity of land resources worldwide makes it **utopian** to assume that organic biogas production could provide a substantial contribution to the worlds energy needs based on renewable energy resources. Lower yields at higher costs and land area needs prohibit a vast expansion of organically produced energy crops. In order to attain the goal of independence from fossil or nuclear energy resources an energy mix of solar, wind, biomass and hydro power is needed. Considering the scarcity of agricultural land for food production the „conventionalization“ of organic biogas production cannot be a reasonable future option (**dead-end**). This would include massive cultivation of energy substrates comprising large transport distances and degradation of soil and biodiversity, leading to aggravated competition for land resources, not only locally but worldwide (ILUC). In addition, this form of bioenergy production would deeply undermine the credibility of organic farming systems both for producers and consumers. Especially considering Central European conditions, the only reasonable practice for organic biogas production (**role model**) seems to be a holistic integrated approach considering a balanced focus on both food production and contribution to increasing energy demands, comprising adapted biogas concepts (meaning small to medium scale, including inter-farm co-operations) with primarily using residues and a moderate and ecologically sound cultivation of energy crops. This approach appears to be able to stabilize both food and energy supply as well as organic farms in general by distributing the entrepreneurial risk through diversification and long-term assurance of productivity without abstaining from secured or even enhanced soil fertility.

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