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Influence of the Biogas Process on the Germinability of Seeds

On fields and grassland, weed control often proves difficult. Rumex obtusifolius in particular can become a problem weed which is hard to control due to its high seed production. If germinable weed seeds get into the slurry, they are spread over the entire area with the liquid manure. Biogas fermentation would allow the germinability of the seeds to be reduced and thus their spreading to be controlled. In Hohenheim, the influence of the biogas process on the germinability of weed- and crop seeds was determined.

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Keywords

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Germinable weed seeds constantly get into the slurry in different ways. This can be the result of pasture mowing, for example, or basal feed dispensing (some seeds even survive the metabolic processes virtually unharmed). Due to slurry application, these weed seeds are spread over the entire area and thus increase the total farm-related weed pressure. Especially *Rumex obtusifolius* can become a problem weed which is difficult to control on both grassland and field areas due to its enormously high seed production. Fermentation of the weed seeds in the biogas plant could reduce or even completely destroy the germinability of the seeds and thus reduce their spreading. This plays a particularly important role in the cofermentation of meadow grass and the fermentation of grain waste, which is often heavily contaminated with weed seeds. This would lead to a positive evaluation of the biogas fermentation of slurry not only with regard to energy generation and improved nutrient utilisation, but also in view of indirect weed control. This is particularly interesting for biological farming.

Goals

The destruction of weed seeds is an aspect that is always mentioned in the literature as an advantage of biogas production [1; 2]. However, this evaluation is generally based on studies on similar topics, such as slurry ventilation [3] or slurry storage [4]. The goal of the studies at Hohenheim University was to find out whether and under what process-technological conditions a reduction in the germinability of weed seeds is achieved in biogas plants.

Methods

In cooperation with the State Institute of Agricultural Engineering and Building Research and the Institute of Plant Cultivation and Grassland of Hohenheim University, a trial was set up on a semi-technical scale in which the germinability of the seeds of eight crop- and weed species was determined depending on different treatment in the biogas plant. The seeds studied were those of winter wheat, *Amaranthus retroflexus*, rape, tomato, *Chenopodium album, Thiaspi arvense*, *Rumex obtusifolius*, and *Sinapis arvensis*.

The fermentation temperature of the substrate was varied (mesophilic operation (35 to 37°C) and thermophilic operation (52 to 55°C)) as was the retention time of the seeds in the fermenter (one, two, and three days; one, three, and five weeks). For biogas treatment, two lying fermenters having a rotting volume of 400 l each were available, which were operated with cattle slurry. In order to obtain practically relevant results, the continuous-flow technique was employed. Therefore, the plants were charged with approximately 20 l of fresh slurry every other day. In addition, the slurry was stirred for five minutes every half hour.

Per treatment variant, 400 seeds of a plant species were sewn into hoses out of water-permeable curtain fabric and immersed into the biogas fermenters. After the individually determined retention time in the fermenter, a seven-week germination test (12 h: 30°C, light; 12 h: 3°C, darkness) in the germination container was carried out with these seeds. Heavy temperature fluctuations and the alteration of light and darkness were intended to cause the highest possible percentage of viable seeds to germinate.

Results and Discussion

The expected reduction in germinability as a result of biogas treatment occurred. The influence of the operational temperature on this process was easy to detect.

After a retention time of 24 hours in the thermophilically operated plant, the seeds of all species examined no longer germinated in the subsequent germination test.

Under mesophilic conditions, the species behaved differently. For winter wheat, rape, *Amaranthus retroflexus*, and *Sinapis arvensis*, a retention time of 24 hours was sufficient to reduce germinability to 0%. *Thiaspi arvense* was slightly more robust, whereas the germination rate of tomato, *Rumex obtusifolius*, and *Chenopodium album* showed virtually no deviation from the untreated control after one day of mesophilic biogas treatment (*fig. 1*).

After one week of mesophilic treatment, the seeds of *Rumex obtusifolius* were no longer able to germinate. *Chenopodium album*, however, whose germinability had hardly decreased after a retention time of three days, proved particularly tough. Only after three weeks was it completely deactivated (fig. 1).

Furthermore, retarded seed germination as compared with the untreated control was established in the mesophilic plant.

The reduction in germinability as a result of biogas fermentation is attributed to different factors. In addition to the pH-value, the seed moisture content, and mechanical influences which may cause damage to the seed coat, the activity of microorganisms is an important influencing factor. During the biogas process, microorganisms convert organic substance into carbon dioxide, water, and methane. The latter is used for energy generation. In the trial, wheat grains showed very clearly that carbohydrates were degraded during these processes in addition to fats and protein. After five weeks in the biogas plant, the largest part of the starch from the endosperm was degraded. The microorganisms had literally „fermented them out" and had only left those substances of the grain behind which were difficult to degrade. During the biogas process, ammonia and hydrogen sulphide are generated. Therefore, the concentration of noxious gases in the biogas slurry increases slightly and can thus also result in a reduction in germinability.

Temperature is likely to play the most important role in damaging the germinability of the seeds. While some species were still able to germinate after shorter biogas treatment in the mesophilic fermenter, the thermophilic termperatures of approximately 52 to 55°C had already halted seed germination after a retention time of 24 hours. This matches earlier results gained from the ventilation of liquid manure [3] or composting [5; 6]. At thermophilic temperatures, the genetic material and enzyme metabolism are damaged so that the seeds become unable to germinate.

The retention time of the seeds in the biogas plant also had an influence on the results. The longer the seeds remained in the biogas plant, the more they lost their ability to germinate. In continuous-flow biogas plants, the real retention time of the substrate in the fermenter is evidently important for this process. Short-circuit flows cannot always be entirely prevented. Since our current agricultural biogas plants generally have hydraulic retention times of more than 40 days and often feature several stages or post-fermentation in the storage container, the real dwell time should be sufficient to kill most weed seeds even during mesophilic operation.

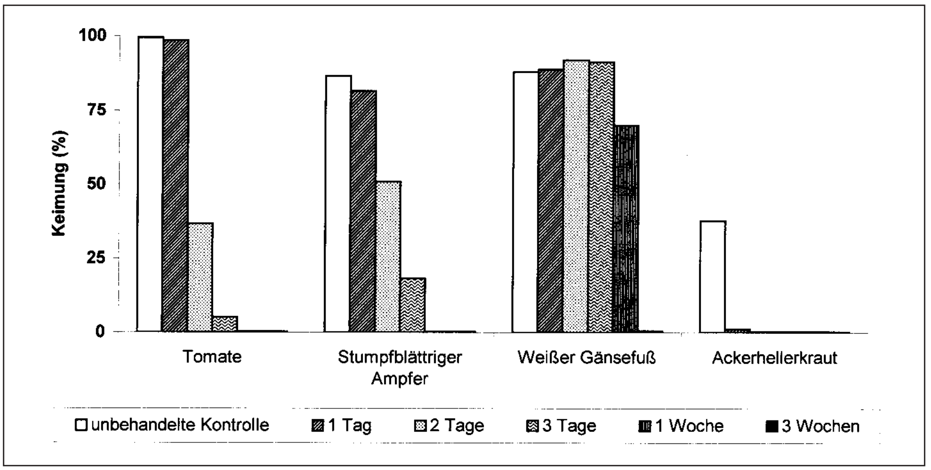

Fig. 1: Germination (% of seeds tested after a seven week's germination test) of tomatoes, broad-leafed dock, meldweed (chenopodium album) and field penny cress (Thlaspi arvense) in the untreated specimen and after different treatment times (1, 2, 3, 7 and 21 days) in a mesophile biogas plant

Summary

The trials carried out show that the germinability of seeds is impaired by the biogas process and that thus the spreading of weed seeds can be reduced. In this process, the seeds of the individual species are damaged to a different extent. In addition to different parameters in the biogas plant, such as the activity of microorganisms, the seed moisture content, the pH-value, and mechanical influences, especially the slurry temperature and the retention time of the seeds in the biogas plant play a decisive role with regard to germinability. If one takes this into consideration when operating a biogas plant, one can assume that the weed pressure due to the propagation of weeds during slurry spreading will be reduced drastically. Hence, problems caused by *Rumex obtusifolius* also diminish.

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