Nitrogen fertiliser value of digestates and untreated cattle slurry differs by organic and conventional crop management

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Introduction

One main obstacle to sustainable nutrient management in organic farming is the scarcity of nutrients. Further, commonly used nutrient sources in organic farming like composts or straw-rich animal manure show low nitrogen (N) fertilizer value. Anaerobic co-digestion of animal manures with biomass from green manures could increase the N fertilizer value of the animal manures while the addition of green manure would result in a higher quantity of fertilizers available in organic farming. Yet, studies investigating N fertilizer values under organic management are scarce. Therefore, this study aimed to determine the N fertilizer value of different products from anaerobic digestion (digestates, separated liquid fraction of digestates) as well as cattle manure and mineral fertilization under organic management. In addition, the difference in fertilizer value due to injection timing (before vs. after ploughing) and crop management (organic vs. conventional) was tested.

Methodology

Two field studies were performed on loamy sand soil at the research station Foulumgaard (56°49'N, 09°58'E). Study 1 compared the effect of injected digestates (co-digestion of cattle slurry and clover grass silage), and liquid fraction from separated digestates with the effect of an unfertilized control, cattle slurry, and mineral fertilization on spring barley yield in two consecutive years under organic management. Study 2 investigated the differences in the fertilizer value of digestates , and cattle slurry due to injection timing (before vs. after ploughing), N dose (100 vs. 200 kg N ha^{-1}), and crop management (organic vs. conventional) in spring barley. The fertilizer value was calculated as N fertilizer replacement value (NFRV) for grain N yield. NFRV is estimated as shown in the equations below from the N use efficiency (NUE) of manures relative to NUE of mineral fertilizer N (determined as the slope of the mineral N response curve). Mineral N was also used as a reference by organic crop management, despite being banned in organic farming.

(1) $NUE=(N_{uptake\ fertilized} - N_{uptake\ unfertilized})/N_{applied}*100\%$ (2) $NFRV=NUE_{manure}/NUE_{mineral}*100\%$

Results and discussion

Study 1 revealed that injected cattle slurry, digestates, and the liquid digestates fraction had all high NFRV between 80% and 90% (based on grain N yield under organic management). Hence, co-digestion of cattle slurry with biomass from green manures can increase the quantity of digestates without lowering the quality. Within the nutrient-limited system of arable organic farming, this could increase the nutrient supply and also be a meaningful use of the biomass from green manures. The separation of the liquid fraction did not result in a higher NFRV. However, it lowered the phosphorous content relative to the N content which can prevent nutrient imbalances, when digestates are used as the only source of N. Study 2 revealed an increase of > 10% points NFRV due to anaerobic digestion (cattle slurry vs. digestate; $F_{(1,49)}$=96.00, p<0.001). It also showed that injection after ploughing compared to injection before ploughing, as often done in practice, can considerably increase the NFRV independent of the kind of fertilizer by around 8% points ($F_{(1,49)}$=24.82, p<0.001). This was probably due to a placement effect when the slurry band was untouched after injection. Further, the estimated NFRV was 13% points higher by organic than conventional management ($F_{(1,3)}$=36.11, p=0.009) which could have caused the relatively high NFRV measured in study 1. It can be explained by a 12% points lower NUE of mineral fertilization under organic management compared to conventional management (t_{30}=7.06, p<0.001). Yet, the NUE of cattle slurry and digestates were not affected by the type of management. A possible explanation could be that a higher weed density by organic farming benefited more from unplaced mineral N fertilizer than from injected manure and reduced crop yields.

Conclusion

Anaerobic digestion can be a useful tool for increasing nutrient efficiency and availability in organic farming. However, when it comes to evaluating the NFRV of organic manures, the application technique and the management of the experiment should be considered. Further research is needed to determine the reasons for a reduced NUE of mineral fertilization under organic crop management while the crop response to injected organic manures seemed to be unaffected by crop management.

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