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Slurry application on grassland: Effects of technique, timing, slurry consistency and sward type

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Abstract

On two grassland field trials in the canton Thurgau (Switzerland) the influence of different slurry application techniques (broadcast, band-spread, trailing-shoe) on yield, botanical composition and forage contamination by slurry residues is investigated. Furthermore, the effect of the timing of slurry application, of slurry consistency and of sward type is tested to derive a best-practice-recommendation for each technique.
At half-time of the three-year experiment duration (2012-2014), no consistent differences could be observed between the application techniques. The slurry application early after the precedent cutting and at thin consistency resulted in tendency in an increased dry matter yield compared to the delayed application of undiluted slurry. Forage contamination by slurry residues seemed to be increased for broadcasted and late applied slurry. After one year of treatment application, sward composition was altered by neither treatment.

Keywords: slurry-application, broadcast, band-spread, trailing-shoe, forage

1 Introduction

Gaseous emissions following slurry application are a major source of atmospheric ammonia (NH_3) content, estimated to account for about 30% of ammonia emissions in Switzerland (Kupper et al. 2013). A concept to minimize the ammonia losses to the atmosphere is to reduce the surface area of the spread slurry combined with a near-ground application. Ammonia emissions after slurry application have been shown to be significantly reduced by band-spread, trailing-shoe techniques or drilling compared to the common broadcast techniques (e.g. Frick & Menzi, 1997, Webb et al., 2010). In some areas of Switzerland the use of low emission slurry spreading techniques has increased due to financial incentives by policy. While the reduction of emissions is well-documented, the effects of these techniques on forage yield, botanical composition and forage quality (i.e. the contamination by slurry residues) are less clear. Although essential to farmers, these parameters have not yet been studied under climatic and farming conditions in Switzerland. Earlier studies from Germany conducted under conditions not common in Switzerland (e.g. pure stands of *Lolium perenne* and sandy soils) revealed conflicting results (e.g. Kiefer et al., 2004, Lorenz & Steffens, 1996).

To derive better knowledge about the effect of the different slurry application techniques on forage production parameters, two field trials were established on temporary grasslands at different sites in the canton Thurgau (Switzerland).

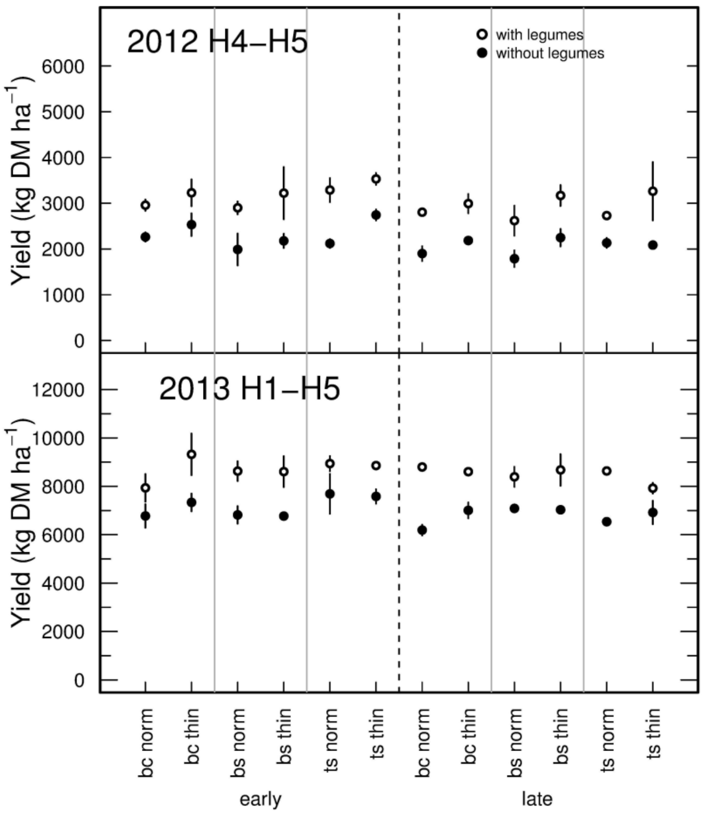
2 Materials and methods

One of the two field trials was established at Tänikon (535 m a. s. l., average annual temperature 7.9°C, 1124 mm precipitation) in a small-plot scale (18 m^2, fully randomized), the other one in about 30 km distance at Arenenberg (470 m a. s. l., average annual temperature 9.4°C, 956 mm precipitation) in a large-plot scale (135 m^2, randomized block design). The field trials were started in spring 2012 and are planned to be run until the end of 2014. The design of the experiment at the Tänikon site includes different slurry application techniques (broadcast, band-spread, trailing-shoe), timing of application (early: 1-3 days after the preceding cutting, late: 7-10 days afterwards), slurry dilution (normal: 4-5% dry matter content, thin: 2-3% dry matter content) and sward type (grass-legume mixture, pure grass stand) in a multifactorial design. At the Arenenberg site, the number of treatments was reduced as the field size was limiting (trailing-shoe and diluted slurry were omitted).
The plots were harvested five times a year (in 2012 there were only two harvests remaining after the establishing phase), and slurry was applied to each regrowth (target values: 30 kg NH_4-N ha^{-1} (Tänikon) or 40 m^3 slurry ha^{-1} (Arenenberg)). Yield was weighted by a plot harvester and plant samples were taken from each plot to determine dry matter and nitrogen content. From a subset of all plots (pure grass stands, undiluted slurry), plant samples were ensiled in 1.5 l laboratory silos and analysed about three months later for silage quality. Soil samples were taken at the start of the experiment and slurry was sampled at each application to determine nutrients content. Botanical composition was determined annually before the third harvest according to the method of Daget and Poissonet (1971).
For the statistical analysis, log-transformed values were analysed using a mixed model of analyses of variance (ANOVA) with application technique, application timing, slurry consistency and sward type as fixed effects. In addition, all interactions were included in this global analysis. Differences between the different treatments were then tested by pairwise comparisons following Holm (1979). All analyses were performed using the statistical software R (R Development Core Team, 2014).

3 Results and discussion

3.1 Dry matter yield

The yield patterns were similar at both experimental sites. Grass-clover stands yielded significantly more than pure grass stands in the first year (Fig. 1: total of harvests 4 and 5) and in 2013 (Fig. 1: total of harvests 1 to 5). This confirms the well-documented positive effect of symbiotic nitrogen fixation by legumes (e.g. Nyfeler et al., 2009). Yield of pure grass stands is limited by the slurry fertilization in this experiment, which is supported by additional legume-free plots fertilized at a wide range of mineral N fertilization.
Significant treatment effects were detected for some single harvests. In tendency, band-spread or trailing-shoe resulted in a higher yield compared to broadcast technique. Moreover, the dry matter yield was in tendency increased when applying the slurry early and at a thin consistency.



bc: broadcast

bs: band-spread

ts: trailing-shoe

norm: viscous slurry (4-5% DM)

thin: diluted slurry (2-3% DM)

early: slurry application 1-3 days after the preceding harvest

late: slurry application 7-10 days after the preceding harvest

Figure 1: Mean values of dry matter yield for the site Tänikon at different application techniques, application timings and slurry consistencies (year 2012: harvest 4-5, year 2013: harvest 1-5). Grass-clover stands (open symbols) and pure grass stands (filled symbols). Standard deviations are shown as vertical lines.

The observed yield advantage at low-emission technique might be a hint to an increased nitrogen availability due to reduced ammonia emissions. The yield advantage with thin slurry might be also explained by reduced ammonia losses due to slurry dilution, while the trend towards increased yield at early slurry application might be attributed to an extended growing period after the fertilisation.

3.2 Botanical composition

Botanical composition was analysed with respect to proportion of grasses, legumes and forbs (Fig. 2: only shown for grass-clover stands at site Tänikon). The mean botanical composition determined in 2012 – i.e. before the treatments were started – reflects the botanical composition typical for intensively managed grass-clover leys several years after establishment. When the releves were repeated in 2013 each plot had got a total of five slurry applications at its assigned treatment. Differences between the treatments could not be detected yet, neither for the site Tänikon nor the site Arenenberg. The reported decline of the legume proportion by low emission slurry spreading techniques compared to conventional application techniques (Kiefer et al. 2004) could therefore not be observed. The lack of significant differences in the botanical composition between the treatments is not surprising at this stage of the experiment. Interactions among the plant species in multi-species communities are versatile (Suter *et al*. 2007). The impact of only slightly altered experimental factors such as the application technique on the botanical composition might only occur after several years.

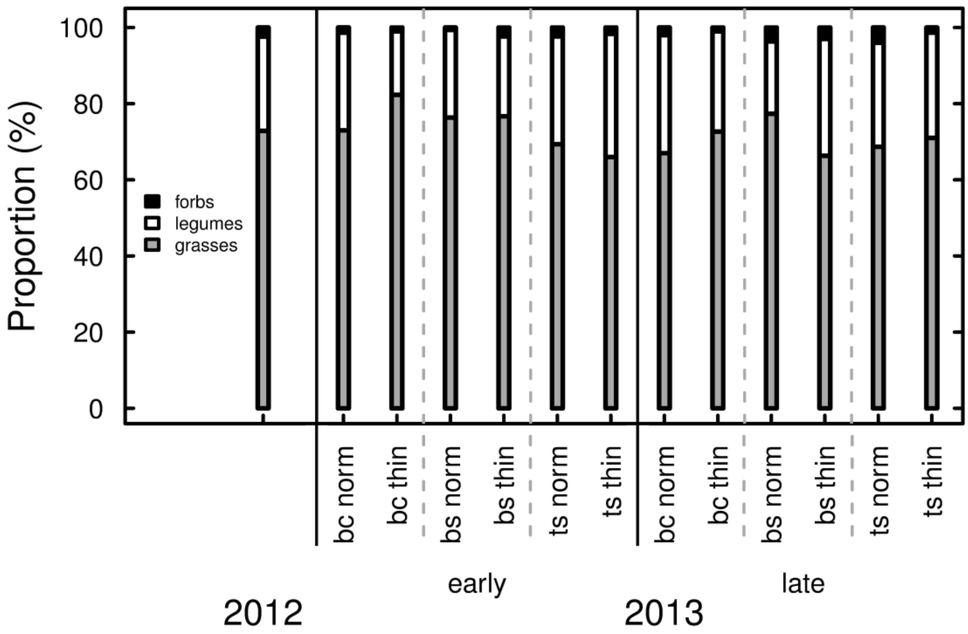


Figure 2: Grass-clover stands at the site Tänikon: mean proportion of grasses, legumes and forbs shortly before the treatments were started (2012: n=36) and after one year applying the different treatments (2013: for each treatment combination n=3).

3.3 Forage contamination

Slurry residues on forage contain clostridial spores, leading to undesired butyric acid fermentation which impairs silage quality. According to Zangerl (1989) fresh forage grass usually contains up to 1000 colony-forming units (CFU) of clostridia spores per gram. However, the plant samples examined in the present experiment in 2013 showed much lower values of clostridia spores with a maximum of 30 CFU/g for broadcasted, late applied slurry (Fig. 3).

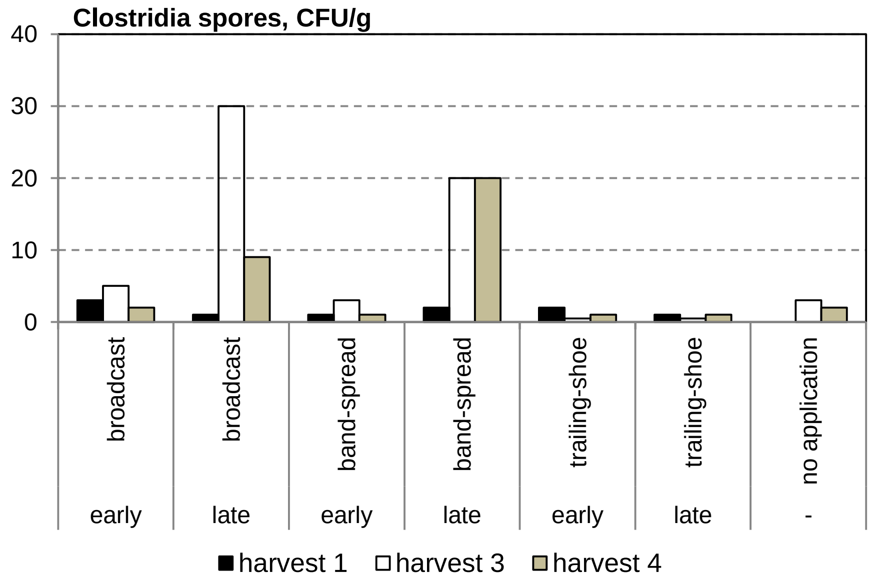


Figure 3: Clostridia spores of fresh forage samples for the site Tänikon in 2013 at different application techniques and application timings (harvest 1, 3 and 4; bulked samples of 3 treatment replications). These determinations were carried out for pure grass stands and viscous slurry only.

Despite the low values of clostridia spores butyric acid was produced during the fermentation process (Fig. 4). All first harvest silages were characterised by a very high butyric acid content indicating unfavourable conditions during the ensiling process, mainly attributed to the low dry matter content (22% on average) at the time of ensiling. For the third respectively fourth harvest silages, butyric acid was in general much lower compared to the first harvest. For these harvests, values for broadcasted slurry application are higher than those for low emission techniques. In addition, a late slurry application was associated with an increased content of butyric acid. These observations confirm the results reported by Lorenz and Steffens (1996).

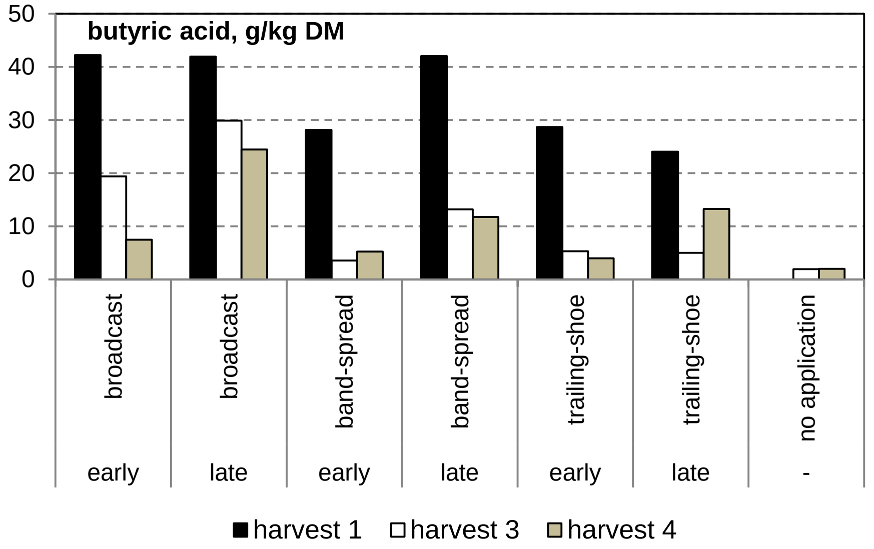


Figure 4: Butyric acid content of ensiled forage samples for the site Tänikon in 2013 at different application techniques and application timings (harvest 1, 3 and 4; bulked samples of 3 treatment replications). These determinations were carried out for pure grass stands and viscous slurry only.

4 Conclusions

The analyses of the preliminary results in this study – i.e. one and a half year – only derived few consistently significant differences among the treatments. While the well-documented yield advantage of grass-clover swards was observed at both experimental sites and almost all harvests, differences between low-emission application techniques and broadcasted application were only small (with a trend towards increased yield for the former). The slurry application at an early stage and at a thin consistency resulted by trend in an increased dry matter yield. After one year of treatment application, sward composition did not differ between the treatments. Results regarding forage contamination by slurry show a tendency of increased contamination for broadcasted application, especially when late applied. We suggest that some of the investigated effects, particularly dry matter yield and botanical composition, need to be studied longer than the period reported here. Interactions among plant species in multi-species swards are complex and relatively weak treatment variations as the differences among the application techniques may provoke significant effects only after several years.

5 Acknowledgements

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