Hinrich Snell, Vechta, with Andrea Kutz and Wolfgang Lücke, Göttingen

# Simulation of the influence of radiation on silage making

## Development of a trial station

*For the standardising of ambient conditions during silage making trials, a trial station was developed which now has already been successfully applied in two experiments. Possibilities for improvement lie in the areas of the radiation sources and temperature control. The trial station offers a great many possibilities for application outside the area of feed conservation too.*

To be able to determine the influences on silage quality of different silage clamp plastic sheeting, a trial station was developed at the University of Göttingen for the simulation and standardisation of the radiation procedures at the silage clamp.

### Construction of the trial station

The trial station (*fig. 1*) offered room for two rows , each of six silage containers (0.3 $m^3$). It consisted of three functional components:

25 mercury vapour lamps (HQL, 400 W) and six metal halogenoid lamps (HQI, 250 W) arranged in three parallel rows served to simulate direct sun radiation. It would have been desirable to have a more application of HQI lamps for intensifying the experiment because these lamps offer a radiation spectrum more similar to sunlight than HQL lamps.

A horizontal glass plate (h = 8 mm) first of all hindered the immediate transmission of long wave heat radiation from the lamps to the silage containers and, secondly, avoided the convective cooling of the containers by the fans now described.

Six radial fans, each with a maximum air displacement capacity of 2785 $m^3$/h cool the glass plate with ambient air. This prevents thermal damage and creates a cool area, especially when the ambient atmosphere has a low temperature, which simulates the cold sky described in [1] and through this makes possible heat reflection radiation of the containers.

Fans and lamps were activated from 8 a.m. to 10 p.m. during the first trial and in the second from 8 a.m. to 6 p.m..

### Performance characteristics of the trial station

Before the start of the ensiling trial, the radiation performance (W/$m^2$) was determined at the upper surface level of the silage containers with the aid of a solarimeter (Kipp and Zonen CM 10, NL). This was initially necessary for determination of the optimal height for lamps. Three different heights were compared and used as criteria were the average performance and the consistency of the radiation conditions. After the final fixing of the lamp level (*fig. 1*) 184 measurements were carried out within a grid pattern of 25•25 cm. The results are given in *figure 2*.

It was clear that the radiation conditions were not absolutely homogenous. The differences were small, however, in the longitudinal direction of the trial station. The differences in the lateral direction affected all the containers equally so that there was no systematic difference to fear, and radiation conditions of sufficient homogeneity should have been possible to achieve. Also clear were the positions of the six HQI lamps. Here, the extraordinary light capacity of these lamps was plain. With 80 lm/W, this is five times more than ordinary light bulbs (15 lm/W) as shown in [2].

The average radiation performance in the trial area was 122 W/$m^2$. Because the trial station covered a greater area than was required for the silage containers, the results in the periphery area can be disregarded. With this in mind, the calculated radiation as an average from 120 measuring points was 149 W/$m^2$. Information in [3] indicates that in the

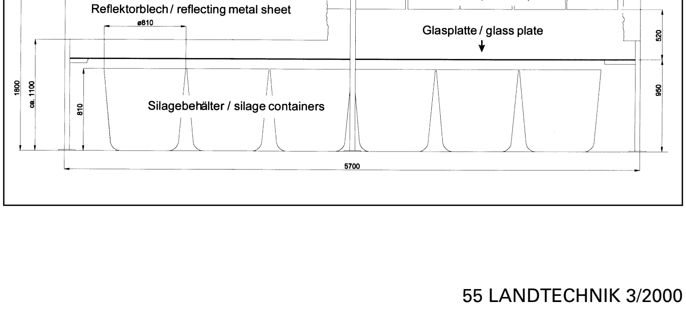


*Fig. 1: Trial station for the simulation of natural radiation influence on silage making (longitudinal view, measurements in mm)*

Dr. Hinrich Snell is scientific assistant at the Research and Study Centre for Value Adding Processes Weser-Ems of the University of Göttingen, Universitätsstrasse 7, D-49377 Vechta; e-mail: hsnell@gwdg.de.
Cand. agr. Andrea Kutz is studying for a diploma at, and Prof. Dr. Wolfgang Lücke is director of, the Institute for Agricultural Engineering of the University of Göttingen, Gutenberg Str. 33, D-37075 Göttingen.

**Keywords**

Silage, bunker silo, silo sheet, cold sky, artificial sky

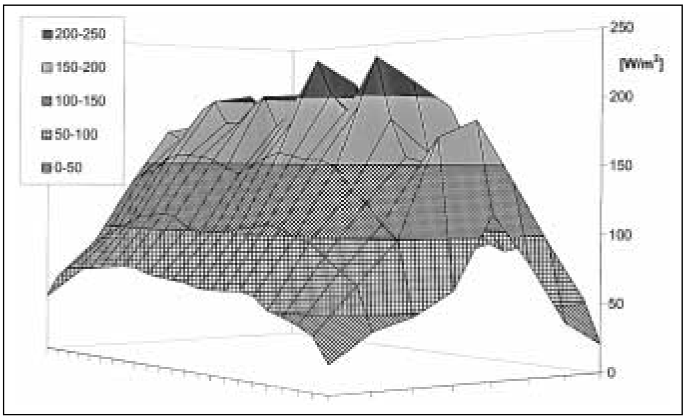


*Fig. 2: Distribution of radiation [W/m²] in the trial station, eight measurement points longitudinally, 23 measuring points laterally*

nearby town of Brunswick radiation in June between 7 a.m. and 6 p.m. regularly exceeds this output. In December not even 100 W/m² is achieved.

The results from the solarimeter and the daily period when the lamps were on in the trial station represents a radiated energy onto the silage containers of around 2.1 kWh/m² in the first trial and 1.5 kWh/m² in the second. [3] reports a daily global radiation as measured in Brunswick which, in long-term average, is less than 2 kWh/m² between October and February but more than 4 kWh/m² from May to August.

A winged wheel anemometer was used to measure the air velocity over the glass plate The average recorded speed was 10 m/s but this represented an underestimation of the actual circumstances through the known difficulties in the measurement of free air streams with winged wheels. A reduction of fan speed which resulted in a drop in wind velocity to around 7 m/s led to no temperature change on the glass plate. A fibre optic measurement on the upper surface with maximum fan speed in high-summer gave temperatures under the plate of 36.7 and above it of 36.6 °C, with reduced fan speed, 36.4 and 35.7 °C respectively. This indicates that a satisfactory simulation of the cold sky is hardly achievable without technical cooling.

#### Comparability with silage making conditions in the field

The question as to whether the use of the described trial station gave reliable measurements could be checked-out in the two already mentioned trials with grass and maize silage. Here, containers with a variety of covers were laid out in three series and also in six series of which two and four series respectively were outdoors, the rest being within the trial station.

It was already clear from the first trial that higher temperatures were present in the trial station – in the silage containers immediately under the covers as well as in the container interiors. Additionally, *figure 3* shows that in the trial station the types of plastic cover were less clearly and less plausibly able to classified according to the temperatures on the silage upper surface. For an explanation here, the different determinates of the silage temperatures must be observed.

The lack of weather-influenced cooling, the protective shelter of the building, and the insufficient simulation of the cold sky led to higher silage container temperatures in the trial station. The latterly mentioned aspect also influenced the difference between the containers with different covers. Different amounts of heat radiation were emitted from different colours of plastic covers. Through the relatively high temperatures of the glass plate, this had less effect on the measurement results as under outdoor conditions.

The results under the green plastic cover in the trial station can be explained through an unwished fermentation, as was confirmed by feed analyses. There is no indication of this sort for the white plastic cover.

Differences in the radiation immediately above the containers with black, green and white 150 µm plastic sheeting (141.7, 149.4 and 153.9 W/m²) are not applicable as explanation examples. Firstly, the differences are quantitatively very small. Secondly, the results show spot-check types of fibre optical measurements which, at the level of the switched-on lamps, gave clear and plausible temperature differences depending on the colour. On the two recording dates (15.6. and 30.7.1999) the upper surface temperature on black, green and white plastic was 37.1, 36.1 and 32.0 °C and 41.0, 40.6 and 36.0 °C.

Finally it is possible that the results were influenced by small amounts of grass that were laid on the measurement sensors in order to protect the plastic sheeting. Differences in the amount of grass could have affected the head conductivity and, with this, the measurement results.

Independently from the question as to whether the results were affected by biological or by technical-experimental factors, parallel repetition is necessary in the investigation of biological processes. Thus, the subsequent trial with maize silage two containers were positioned under the trial station for every variant of plastic cover. During this trial too, the temperatures were higher than those under outdoor conditions. Decisive for the transferability of results was, however, the fact that no statistically-significant interaction regarding silage temperature between site and plastic film type was able to be registered.

## Literature

Books are signified with •

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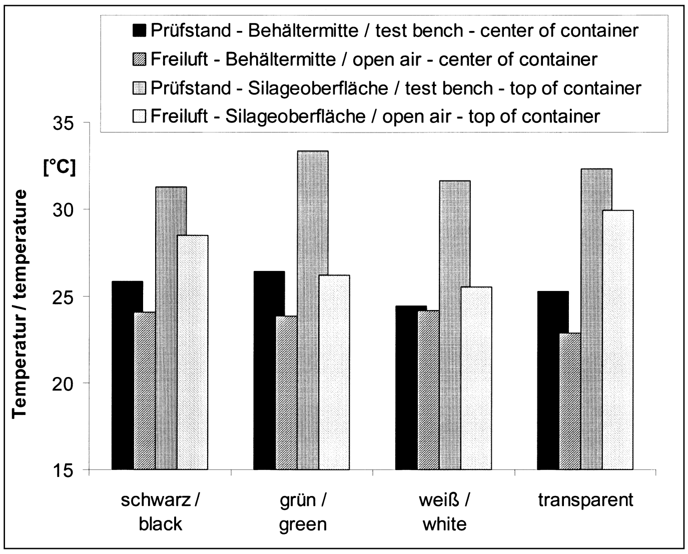


*Fig. 3: Temperature [°C] of grass silage in association with the type of silage plastic sheeting, site and silage horizon*