Different methods of yield recordings in grassland – how accurate are they in practice?

Comparison and use of digital tools for measuring and estimating yields in grassland in standing crop and after cutting

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Abstract: The aim of the study is to determine the yields in grassland using various methods. Yield recording in grassland has not been common practice so far. Yields can be recorded using various methods as height measurement, for example by using a rising-plate-meter (Grasshopper), measuring the weight of sample cut or by capturing the weight of harvested biomass. A yield estimation with the Grasshopper is carried out on three plots and is validated via sample cuts. The harvest chain is recorded digitally and the harvest quantity (weight) is measured with the load cells in the loader wagon, a validation is carried out via a wagon scales. The results presents underestimated yields when using the Grasshopper. The recording of harvest weights via the loader wagon's load cells was confirmed by the wagon scales. This method can be easily used in practice, if available. However, a determination of the dry matter content remains key. The correct determination of dry matter is crucial for accurate yield recording, but this is where very great challenges lie, especially for practice. Further investigations have to be carried out.

Keywords: yield estimation, Grasshopper, grassland, annual yield, digital yield recording

1 Introduction

Measuring or estimating yields in grassland is laborious and rarely done in practice. Yields can be measured before harvesting or after harvesting, taking field losses into account. So far, grassland yields have not been measured at the research station in Aulendorf. In the following study, various methods will therefore be used. Among other things, an estimation is to be made in the standing crop by measuring the compressed sward height with a rising-plate meter called Grasshopper. Especially for intensive grass swards such as ryegrass-white clover meadows, this estimate can already predict an accurate yield for the farmer via an appropriately stored regression curve [Mc19]. In addition, the yields will be measured using the load cells on a short-cut loader wagon and validated via a wagon

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scales. The aim of this study is to collect the yields in grassland using practical and also digital methods specifically at the research station Aulendorf and to check the accuracy in the process.

2 Materials and methods

Yields were recorded on three plots with five cuts in Aulendorf. The measurements were carried out on 09 May 2022 for the first cut (silage), on 10 June 2022 for the second cut (silage), on 11 July 2022 for the third cut (hay), on 31 August 2022 for the fourth cut (silage) and on 17 October 2022 for the fifth cut (silage). For this purpose, three plots were selected, which were as homogeneous as possible. The areas Hillacker, Bohnerwiese and Lenzenbreite are located around Aulendorf. Their altitude is approx. 570 m above sea level with an average temperature of 7.6 °C and an annual precipitation of approx. 902 mm. The average daily hours of sunshine are 4.5 hours.

Before cutting in the standing crop, sward measurements were carried out within a trial frame (TF). For this purpose, three TF with a frame size of 1 m² were randomly distributed on the field, the compressed sward height was measured in advance with the Grasshopper (GH) within the trial frame at 9 points with a preset cutting height of 50 mm and a dry matter content of 18 %. The GH measured the compressed sward height in mm and estimated yields by means of a deposited, unpublished equation. The area was cut manually with battery shears to a cutting height of approximately 50 mm, the fresh mass was measured. For the determination of the dry matter content, sample cuts were dried at 105 °C for more than 24 hours in the drying cabinet until the weight was constant. The sward was assessed within the TF for the composition of grass, herbs and legumes, and the gap percentage was determined. Grasshopper measurements were also taken on the total area in a specific pattern (EGH).

After cutting, the yields were recorded via the loader wagon with load cells (manufacturer Maschinenfabrik Bernard Krone GmbH & Co. KG, designation short-cut loader wagon ZX 450 GD with integrated weighing device via weighing measuring bolts on drawbar and axle unit) and via wagon scales. A composite sample was formed from each loader wagon and taken from the silo in order to be able to determine the dry matter content.

The measured yields within the TF are compared with the GH yield estimation within the TF before cutting. For the first cut, the weight measurement of the loader wagon was additionally validated. The yield of the loader wagon was measured once via load cells on the field (EL) and on a flat surface in front of the silo (ELS) and validated with a wagon scales (EF). An overview of the different measurement treatments and their abbreviations is given in Table 1.

The statistical evaluation was carried out with the programme Microsoft Excel 2016 and R (version 1.4.1717).

Treatment	Abbreviations
Trial frames	TL
Grasshopper within the trial frames	GH
Grasshopper total area	EGH
Loader wagon with the load cells in the field	EL
Loader wagon with the load cells on flat surface	ELS
Loader wagon on wagon scales	EF

Tab. 1: Description of the treatments and addreviations used in the study

3 Results and discussion

3.1 Dry matter content

The dry matter content before cutting is about 15 to 19 % and increases differently depending on the area, in the case of silage use to 26 to 40 % and in the case of use as hay to about 84 to 88 %. For the measurement of yield, the dry matter content is essential. The differences in dry matter are particularly striking. If this is estimated but not measured, this already results in large estimation errors.

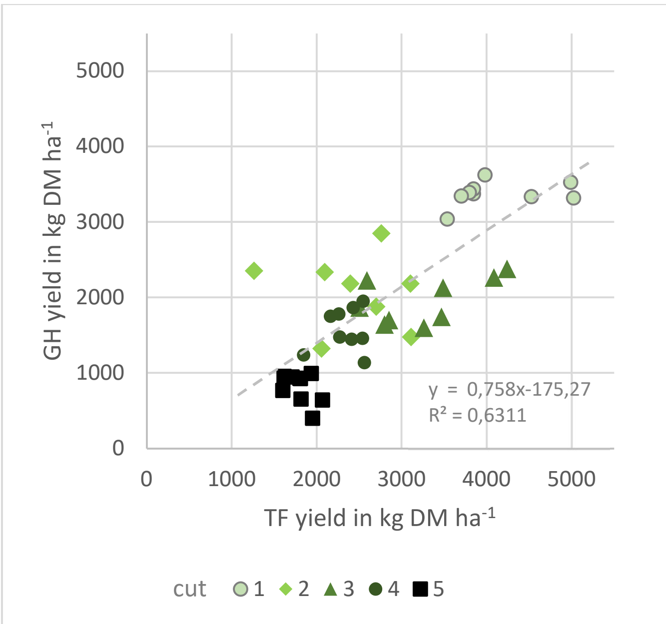

Fig. 1: Comparison of the measurement results of the sample cuts within the trial frames (TF) to the yield estimate of Grasshopper (GH) within the trial frames for each cut (1-5)

3.2 Accuracy of yield estimates with the Grasshopper

The measurements of TF in comparison to GH are shown in Figure 1. It is striking here that the Grasshopper underestimates the yield on all plots in almost every cut. Therefore, a statement of the yields in the cutting use with the Grasshopper was not perfect in this experiment. To improve the grasshopper estimation by Stumpe et al. the estimation is adapted to other factors such as location, time of season and stock [St22].

3.3 Accuracy of the weight measurement on the loader wagon

The weights of the harvested quantity in fresh mass were also measured with the loader wagon and the wagon scales (Fig. 2). The EL, EF and ELS measurements correspond very well for practice, the differences lie at +/- 400 kg fresh mass (FM). The yield measurements via the load cells of the loader wagon are therefore a very good method for getting an overview, if available. However, for the estimation of grassland yields on a farm the dry matter content is absolutely essential.

Fig. 2: Recording the harvest weight on the Bohnerwiese, Hillacker and Lenzenbreite areas via different methods, the weight is measured via the load cells on the loader wagon directly in the field (EL), via the load cells on the loader wagon in front of the silo plate on a flat surface (ELS) and the weight is measured with the wagon scales (EF) for L1, L2 and L3 (loader wagon 1-3)

3.4 Annual yield

Recording yields in agriculture, especially in grassland, is key to record annual yields. For this purpose, it is important that the yields are available for each cut. In grassland, different harvesting methods are used throughout the year, from forage harvesters to loader wagons to baling. Intermittent grazing can also be problematic for recording the annual yield. The aim is therefore to estimate an annual yield and also to be able to take various methods into account.

The yields differ depending on the area and method (Fig. 3). Overall, the yields are in the average range of the last few years for the Aulendorf site and a 5-cut meadow, the first cut in particular was above average. Yields cannot be directly compared because TF and EGH were measured in the standing crop and EL, on the other hand, were measured after harvest with field losses of approxomatily 10 % [Ko13]. Due to the implementation of various procedures, values are missing for EL in the fourth and fifth cut. Hence, these missing values for EL (Bohnerwiese, Hillacker and Lenzenbreite) fourth cut and EL (Hillacker) fifth cut were estimated.

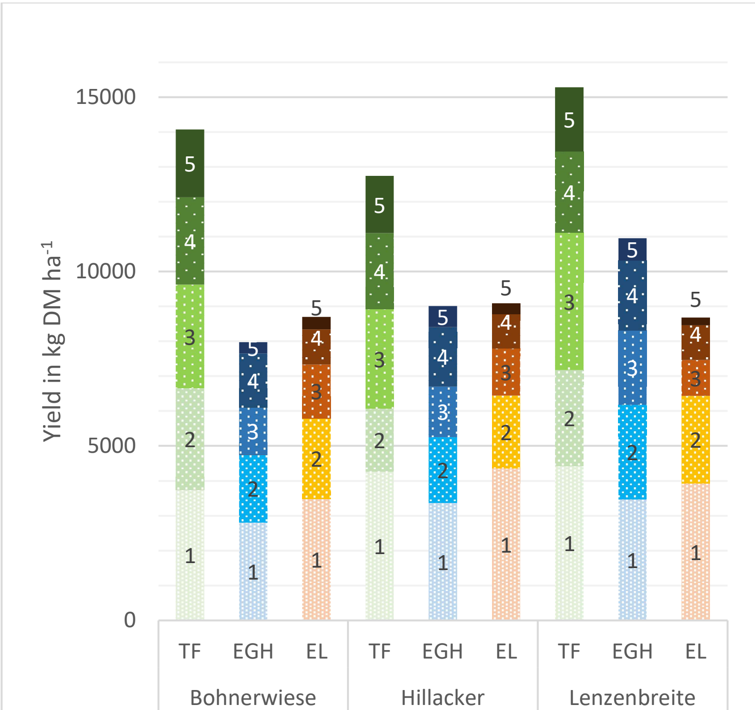

Fig. 3: Annual yield divided into individual cuts (1-5) for all three plots (Bohnerwiese, Hillacker and Lenzenbreite) with different measuring methods such as sample cuts within the trial frames (TF), the Grasshopper measurements taken on the total area (EGH) and via the load cells on the loader wagon directly in the field (EL)

In 2022, an average annual yield of approx. 90 dt DM ha^{-1} was achieved on these three areas in Aulendorf when measured with the loader wagon (Tab. 2). This yield was actually removed from the field and, accordingly, this proportion of nutrients left the field. Under the fertilizer ordinance, yields for a 5-cut meadow in Baden Württemberg are given as

110 dt DM ha^{-1} [Me22]. For grassland stands, it is already progress that measurements have been taken and the values are already going in the right direction.

	TF	GH	EGH	EL
Bohnerwiese	14074	8763	7978	8700
Hillacker	12742	9756	9013	9088
Lenzenbreite	15284	10651	10953	8683

Tab. 2: Annual yield in kg DM ha^{-1} with different measuring methods such as sample cuts within the trial frames (TF), the Grasshopper measurements taken within the trial frames (GH) and on the total area (EGH) and via the weighing cells on the loader wagon directly in the field (EL)

4 Conclusion

It is very difficult to determine the yield reliably with methods available in practice. Even a digital tool such as Grasshopper could not simplify the determination of yield. However, the use of a loader wagon with load cells is recommended for individual cuts. There is a lack of further research on how different measuring methods can be meaningfully combined into an annual yield. An automated recording of the yield measurements and a corresponding transfer to farm management information systems are also important for the future. It will be important for farmers to get a value for each cut and for classification. And then there is the fact that it has to be even more precise.

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