Amazing Grazing: grass growth measurements with remote sensing techniques

Hoving I.E.[1], Starmans D.A.J.[1], Booij J.A.[1], Kuiper I.[2] and Holshof G.[1]
[1]*Wageningen University and Research, P.O. Box 9101, 6700 HB Wageningen, the Netherlands;* [2]*Agrifirm Plant BV, P.O. Box 20000, 7302 HA Apeldoorn, the Netherlands*

Abstract

Quantifying grass production is considered essential for adequate grassland management on grass based dairy farms. Spectral imaging with remote sensing techniques could be an alternative for labour intensive grass height measurements. In a cutting experiment with a factorial combination of nitrogen fertilisation and grass growth intervals, grass growth was measured with a Cropscan Multispectral Radiometer measuring light reflectance in eight or 16 bands (ground truth measurement). The aim of the experiment was to see whether vegetation indices can be used to quantify actual grass biomass. Preliminary results of the first year of the project showed that some vegetation indices were well related to grass yield. However, this relationship was best for individual cuts, meaning that correlations were changing during the growing season.

Keywords: Amazing Grazing, remote sensing, spectral imaging, grass, vegetation indices, DM yield

Introduction

Remote sensing technics are developing rapidly and are gaining ground in agriculture by the use of multispectral cameras integrated in satellite, drone or handheld appliances. Spectral imaging shows potential to get insight into actual grass production, as the rate of light reflection can be translated to vegetation indices. Proper prediction of biomass and its nutritional value is considered essential for modern day grassland management on grass based dairy farms. As such, spectral imaging techniques could provide an alternative for labour intensive grass height measurements. To explore these perspectives, an experiment on multiple types of soil (clay, sand and peat) was set up. The experiment was designed to run from 2016 to 2018 and the aim was to see whether vegetation indices could be used to quantify actual biomass. Grass growth was monitored with both nearby and remote sensing devices. This paper describes the preliminary results.

Materials and methods

In 2016, an experiment was commenced with the aim to relate weighed dry matter (DM) yield to spectral images. In order to achieve normal variation in hydrological conditions and mineralisation levels of nitrogen, the experiment was set up on a Dutch clay, sand and peat soil. A factorial combination of nitrogen fertilisation (0, 180 and 360 kg ha^{-1}) and grass growth intervals were provided to create various yield stages. The aim was to have a broad measuring range on one specific moment to relate spectral images to DM yield. The total number of plots was 24 per location (three nitrogen levels × four growth intervals per cut × two repetitions). The four growth intervals existed of three interim trimmings (weekly, each on six plots) and a 'final' cut of all 24 plots. The number of final cuts per location was five (clay and peat) to six (sand) and covered the entire growing season. The experimental plots were about 20 × 20 m in size to be visible on satellite and drone imagery. At the moment of the final cut, a day before harvest, light reflectance was measured with a calibrated Cropscan Multispectral Radiometer (MSR87, MSR16R). The clay (2016 - 2017) and peat (2017) location were measured in 16 bands between 460 - 1080 nm. The sand location was measured in eight bands between 460 and 810 nm, whereby five bands were corresponding with bands of the 16 bands Cropscan. Therefore, the equipment difference was not limiting data analysis. The reflection at 560 nm, 660 - 670 nm or 760 nm were combined with the reflection at 810 nm using several algorithms called vegetation indices. Four common vegetation indices were used, which included NDVI (Rouse *et al.*, 1973), WDVI red (Clevers, 1989), WDVI green (Bouman *et al*, 1992) and NDRE (Eitel *et al*., 2010). The harvest was done by cutting two strips of 1.5 × 8 m per plot with a Haldrup™ harvester for experimental fields. Fresh grass yield was weighed and DM content was determined by drying grass samples for 24 hours in a stove at 70 °C.

Results and discussion

For the three locations, a relatively small range of light reflections was found at 460 - 560 nm and a relatively broad range of light reflections was found at 760 - 810 nm. Wavelengths higher than 810 nm did not give deviating results. For all five final cuts of the clay location (2016), the indices were plotted against DM yield (Figure 1).

The results could be fitted using an exponential relationship with R^2 coefficients between 0.34 and 0.61. WDVI red was best related to DM yield based on the calculated R^2 coefficient, although the difference between WDVI red and green was relatively small. However, due to a high variation in results, yield could not be predicted reliably using a single algorithm for the complete growing season. Furthermore, the relationships were different per location. An important improvement of the relationships could be realised by distinguishing the different cuts (Figure 2) per location.

The results showed exponential relationships with R^2 coefficients between 0.87 and 0.93 for cuts 1 - 4. However, by the end of the growing season, cut 5 WDVI red was hardly related to DM yield, because of low yields. Relatively high reflection percentages were related to relatively low DM yields in cut 2. Although it is not known why the correlation is changing during the growing season and between locations, a number of reasons should be considered. Possible explanations include a change in composition of biomass (N - content, DM content) leading to change in base absorbance. Similarly, the orientation of foliage triggered by grass length differences between cuts and flowering could influence reflectance. We expect further analysis to offer more insight into this matter. Furthermore, it has to be remarked that the current results are obtained under mowing conditions. Therefore, it is also the question how heterogeneity due to grazing will impact the correlations. Answering this question will be part of the Amazing Grazing project in 2018 (Schils *et al.*, 2018).

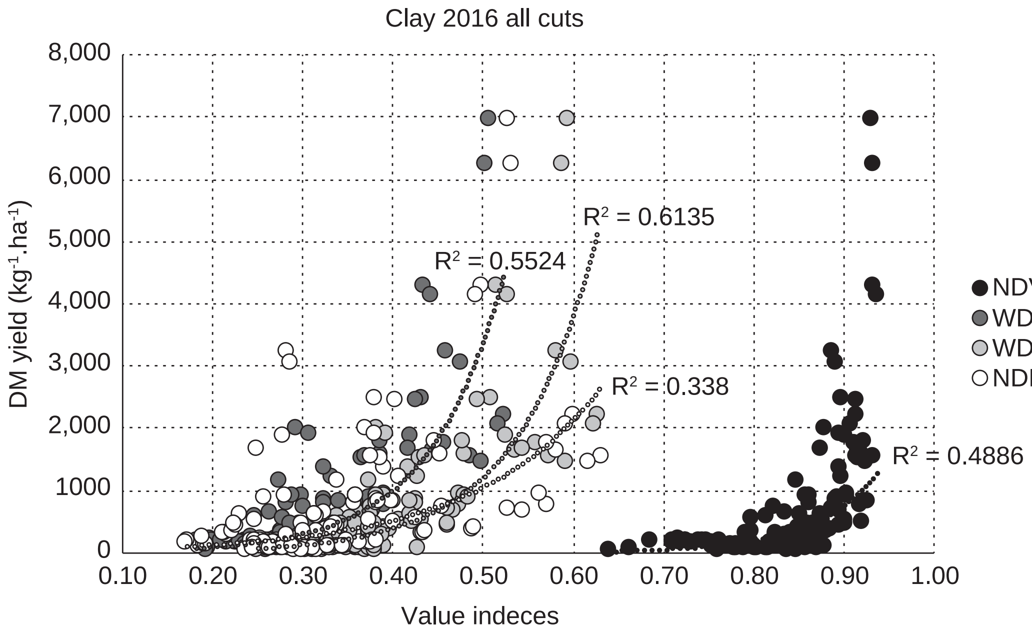

Figure 1. NDVI, WDVI green, WDVI red and NDRE plotted against DM yield for all cuts of the clay location in 2016.

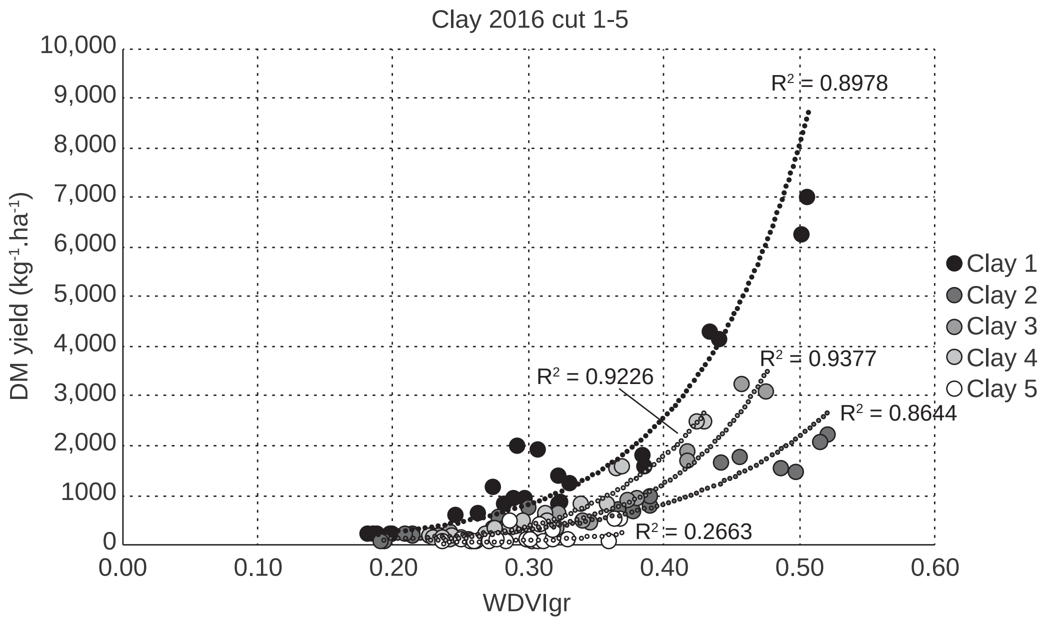

Figure 2. WDVI red plotted against DM yield per cut (1-5) for the clay location in 2016.

Conclusion

Preliminary results of the experiment showed that some vegetation indices were well related to grass yield. However, this relationship was best for individual cuts, meaning that correlations were changing during the growing season. Results varied per location. More insight into those matters is desired, as well as the impact of heterogeneity due to grazing. In the meantime, spectral imaging is helpful to get an insight into yield variation between grass plots and within grass plots under similar growing conditions.

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References

Bouman B.A.M., Uenk D., Haverkort A.J. 1992. The estimation of ground cover of potato by reflectance measurements. *Potato Research* 35:111-125.

Clevers J.G.P.W. (1989) The application of a weighted infrared-red vegetation index for estimating leaf area index by correcting for soil moisture. *Remote Sensing of Environment* 29, 25-37.

Eitel J.U.H., Keefe R.F., Long D.S., Davis A.S., Vierling L.A. (2010) Active Ground Optical Remote Sensing for Improved Monitoring of Seedling Stress in Nurseries. *Sensors* 10: 2843-2850.

Rouse, J. W., R. H. Haas, J. A. Schell, and D. W. Deering (1973) 'Monitoring vegetation systems in the Great Plains with ERTS', Third ERTS Symposium, NASA SP-351 I, 309-317.

Schils R.L.M., Philipsen A.P., Holshof G., Zom R.L.G., Hoving I.E., Van Reenen C.G., Van der Werf J.T.N., Galama P.J., Sebek L., Klootwijk C., Van Eekeren N.J.M., Hoekstra N.J., Stienezen M.W.J., Van Den Pol - Van Dasselaar A. (2018) Amazing Grazing; science in support of future dairy systems. This volume.

MSR87 and MSR16R, CropScan Inc., Rochester, MN, USA, http://www.cropscan.com