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Advances in Nutrient Management of Grass Seed Crops

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Advances in nutrient management of grass seed crops

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Abstract. Nutrient management of herbage grass seed crops is just as complex as for other agricultural crops when the aim is to optimise economic net return and minimise environmental impact. The use of economic optimum nitrogen (N) application rate (ECO-N) defined as the N application rate that maximise net return for the seed grower is an easy and applicable method for seed growers. Besides the economic advantages of implementing ECO-N there is an additional positive environmental effect as ECO-N is lower than the N rate that maximises seed yield and a lower N application rate will concomitantly lower the potential risk of N leaching. Another interesting but not yet implemented method for N management in grass seed production is the use of canopy reflectance and calculation of crop index or using data for multivariate data analysis to measure plant N status and predict seed yield. The use of canopy reflectance in combination with critical N dilution curves is very interesting and promising. The practical way of using these methods would be to measure plant N status, compare estimated plant N status with critical N status and intervene by applying more N if necessary. Grass seed production is a biological complex process and focusing on N will only succeed if other nutrients, water and the seed yield potential are not a limiting factor for the final seed yield.

Keywords: Nitrogen, seed yield, N use efficiency, critical N dilution curves.

Introduction

Nutrient management and especially nitrogen (N) management of grass seed crops faces the same challenges as most other agricultural crops – how do we increase yield while decreasing the risk of N leaching to ground and surface water which we all are highly dependent on. It is not an easy task but if we start by redefining ‘increase seed yield’ to ‘optimise economic net return *e.g.* €/ha, we have solutions and more solutions will be developed during the next years. It is important to remember that grass seed crops are among the agricultural cultivated crops with the lowest leaching of nitrate (kg/ha) according to the Danish *Nitrate Leaching Estimator* ver. 4. (N-LES$_4$) (Kristensen *et al.* 2003). Nitrate leaching from the 19 field observations with herbage seed grass followed by a grass crop was 20 kg/ha (Kristensen *et al*. 2003). Economic optimum nitrogen (N) application rate (ECO-N) defined as the N application rate that maximise economic net return for the seed grower is very important for seed growers (Gislum *et al*. 2007). ECO-N also have an environmental influence due to the fact that N requirements for optimum seed yield is higher than for ECO-N and lowering the N rate will inevitably lower the N amount to be potentially leached.

Nitrogen, seed yield and seed yield components

Herbage grass seed crops are temperate crops and need vernalisation before they can start reproductive development. Herbage grass seed species can be divided into two groups, the first group being the species where both autumn and spring N applications influence final seed yield (*e.g.* red fescue (*Festuca rubra* L.), kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*F. arundinacea* Schreb.) while the second group of species has in most cases, no need for an autumn N application (*e.g.* perennial ryegrass (*Lolium perenne* L.). Another difference between these two groups is the relation between number of fertile tillers and seed yield. In cases where autumn N interacts with spring N there is a positive correlation between number of reproductive tillers and seed yield and in this case seed yield potential is established in the autumn. N applied in the autumn aims to increase the yield potential by increasing the number of reproductive tillers. Spring N application aims to utilise the seed yield potential by increasing the remaining seed yield components and this is the time during the growing season where most research on N management has been done.

Critical N dilution curves (NDC)

Plant N status (%N of dry matter) decreases during the spring and summer growing season due the dilution of N, while N content (kg N uptake/ha) increases (Fig. 1). Both N status and N content curves are dependent on N application rate. Lemaire and Gastal (1997) then developed the concept of *critical N dilution curves* (NDC) for different agricultural crops and Gislum and Boelt (2009) developed it for (forage) grass seed crops. Based on the NDC it should be possible to define if N is the limiting factor for seed yield. Based on a series of field experiments, an NDC has been developed for perennial ryegrass seed crops (Fig. 2).

The limitations in the use of NDC for practical purposes lies mostly in the fact that N is very seldom limiting during the early spring growing season due to a low biomass in the field and therefore a concomitant low demand for N, and this is the reason for the high N status at

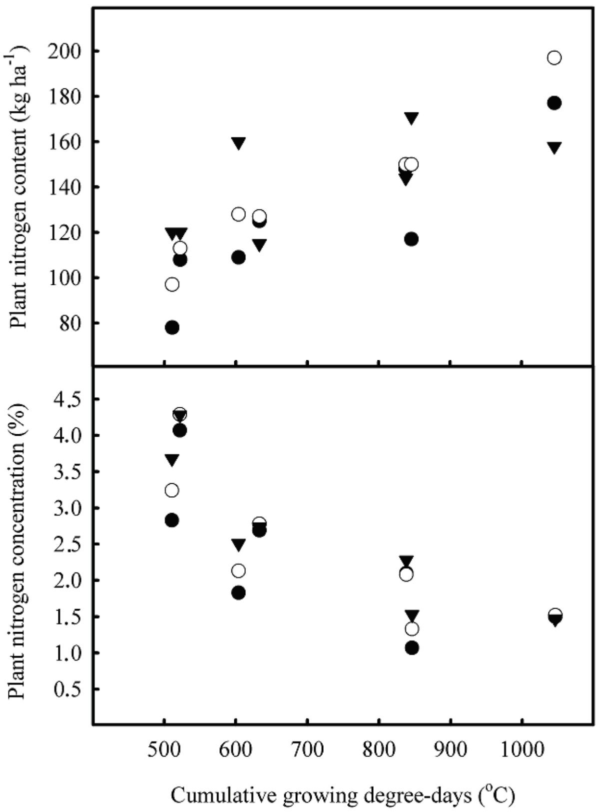

Figure 1. Plant nitrogen (N) content (kg/ha), and plant N concentration (%) plotted as a function of cumulative growing degree-days for 80 kg N/ha (●), 115 kg N/ha (○), and 150 kg N/ha (▼) as an average of three sowing rates. All values are means of four replicates. (Gislum *et al*. 2009).

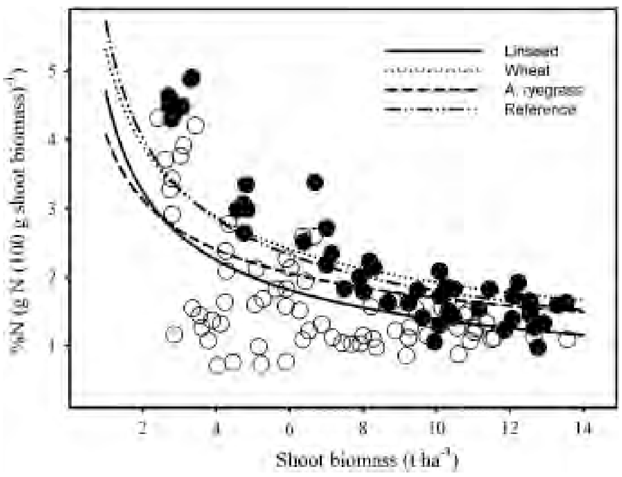

Figure 2. Examination of reliability of critical nitrogen dilution curves corresponding to different species plotted with shoot N concentration vs. shoot biomass in perennial ryegrass from datasets 12 to 17 and 24 to 41. Closed circle●)(are results from nitrogen application rates that were not limiting for seed yield. Open circles indicate nitrogen application rates that were significantly different. (Gislum and Boelt, 2009)

initiation of spring growth. As biomass production increases N can become a limiting factor and results from field experiments has shown that the period from 428 to 540 GDD-days is the period with the largest variation in

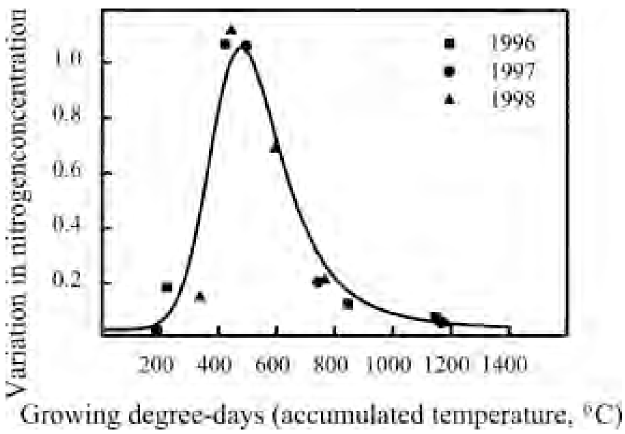

Figure 3. Variation in plant nitrogen concentration in 1996-1998 plotted as a linear function of growing degree-days. Symbols indicate measured variation, solid line is the fitted curve. (Gislum *et al*. 2005)

plant N status (Gislum *et al*. 2005). This period, under Danish growing conditions, was during stem elongation, which seems logical as biomass production increased and N might then become a limiting factor which is measured as a decrease in plant N status.

Canopy reflectance and herbage seed yield

The positive correlation between plant N status and grass seed yield has been investigated since 2005 and it is clear that some positive relations exist. However, for practical purposes the idea of taking plant samples and analysing the samples for total N is not the solution even though a fast method for measuring total N in grasses using near infrared reflectance spectroscopy has been developed (Gislum *et al*. 2004) (Fig. 2). The use of a fast and non-destructive method of canopy reflectance to calculate the normal difference vegetation index (NDVI) was therefore developed to replace the NDC. In this way it should be possible to replace the time consuming and labour intensive plant sampling with a fast and non-destructive measurement of canopy reflectance in order to estimate if N was a limiting factor for seed yield. The principle of a critical NDVI curves is essentially the same as NDC.

Based on a three year field experiment in perennial ryegrass it was shown that the highest correlation coefficients between NDVI and seed yield was in the period from 700 to 900 cumulative GDD (base temperature of 0^{o}C and start date of 1st January) and that is was possible to predict seed yield (R^2 0.9) during this time frame (Gislum and Boelt, 2010) (Fig. 3). By the use of multivariate data analysis (partial least squares regression) it was possible to predict seed yield in perennial ryegrass (R^2 0.71 to 0.92, 3 replications) of a one year field experiment (Gislum *et al*. 2009). The highest correlation coefficients were achieved from 600 to 900 cumulative GDD (Gislum *et al*. 2009). 100 cumulative GDD is approximately 8 days at this time of the year.

The practical purpose of using NDVI to estimate plant N status would be that the seed grower has to intervene at a NDVI value lower than 0.9 by applying more N. This period is later than the period of largest variation in plant N status which is not surprising as first we observe a variation in plant N status and later this variation influences seed yield. Unfortunately the period from 700 to 900 cumulative GDD is just before and at heading and during this time we will not recommend an additional N application at this growth stage due to low utilisation of N at this growth stage.

Conclusion

The first and obvious steps to optimise economic net return and lower the risk of N leaching in herbage seed production is to develop and implement ECO-N in practical seed production. Next step is to utilise the potentials of canopy reflectance to measure plant N status and predict seed yield. Forage grass seed production is a biological complex process and focusing on N will only succeed if other nutrients, water and the seed yield potential are not a limiting factor for final seed yield. The work on nutrient management is an on-going activity at Aarhus University, Denmark and we will establish field, growth chamber and semi-field experiments in 2013 where at least one of the treatments include nitrogen.

References

Gislum R, Chynoweth R, Boelt B (2012) The use of seed and straw N concentration to estimate NUE in perennial ryegrass for seed production – a case study from Denmark and New Zealand: 12th Congress of the European Society for Agronomy, Helsinki, Finland, 20-24 August 2012.

Gislum R, Deleuran LC, Kristensen K, Boelt B (2012) Optimum distribution between autumn-applied and spring-applied nitrogen in seed production of tall fescue. *Journal of Plant Nutrition* **35,** 1394-1410.

Gislum R, Boelt B (2010) Modelling NDVI curves in perennial ryegrass: Proceedings of the 7th International Herbage Seed Conference, Dallas, Texas, USA, 11-13 September 2010.

Gislum R, Boelt B (2009) Validity of accessible critical nitrogen dilution curves in perennial ryegrass for seed production. *Field Crops Research* **111,** 152-156.

Gislum R, Deleuran LC, Boelt B (2009) Predicting seed yield in perennial ryegrass using repeated canopy reflectance measurements and PLSR. *Acta Agriculturae Scandinavica, Section B – Soil and Plant Science* **59**, 414-423.

Gislum R, Rolston P, Hart JM, Chynoweth R, McCloy B, Young WC III (2007) Economical optimal nitrogen (ECO-N) application rate is all that matters for the growers: Proceedings of the Sixth International Herbage Seed Conference, Gjennestad, Norway, 18-20 June 2007.

Gislum R, Boelt B, Jensen ES, Wollenweber B, Kristensen K (2005) Temporal variation in nitrogen concentration of above ground perennial ryegrass applied different nitrogen fertiliser rates. *Field Crops Research* **91,** 83-90.

Gislum R, Micklander E, Nielsen JP (2004) Quantification of nitrogen concentration in perennial ryegrass and red fescue using near-infrared reflectance spectroscopy (NIRS) and chemometrics. *Field Crops Research* **88,** 269-277.

Kristensen K, Jørgensen U, Grant R (2003) Genberegning af modellen N-LES. Baggrundsnotat til Vandmiljøplan II – slutevaluering.

Lemaire G, Gastal F (1997) N uptake and distribution in plant canopies In: Lemaire G (ed), diagnosis of the nitrogen status in crops. Springer-Verlag Publishers, Heidelberg, ISBN 3-540-62223-3, pp 3-43.