Carbohydrates in Perennial Ryegrass Seed Crops

**Key Points**

- This study was undertaken to:
  1. determine if carbohydrate production was limiting seed yield in perennial ryegrass; and
  2. improve the understanding of plant/seed development.
- During the growing season, grasses have two main forms of water-soluble carbohydrates; low molecular weight (LMW) and high molecular weight (HMW). Low Molecular weight carbohydrates are transportable within the plant while HMW carbohydrates cannot be moved.
- Total amount of water-soluble carbohydrates in the plant following anthesis (flowering) does not limit seed yield, however the distribution and remobilisation of carbohydrates to the seed is a factor limiting seed yield.
- If more water-soluble carbohydrates, principally LMW can be remobilised to the immature seed there is potential to improve seed yield in perennial ryegrass.

**Introduction**

Forage grass seed yields are often low and variable with only 10-20% of the above ground dry matter harvested as seed. Seed yield is affected by the amount of carbohydrate transported to the seed; therefore knowledge of the different types and amounts of carbohydrates that are synthesised in different tissues and transported to the seed is fundamental for a better understanding of factors limiting seed yield. Forage grasses and cereals contain the most diverse structural and non-structural carbohydrates of all known plants. In the seeds and grains of forage grasses and cereals, starch is the major non-structural storage carbohydrate. However, for much of the growing season starch is often only a minor component of the total carbohydrate present in the plant.

Vegetative tissues of cereals and temperate grasses, such as perennial ryegrass (*Lolium perenne* L.), accumulate water-soluble carbohydrates (WSC), often in high concentrations. These carbohydrates, stored in leaves and stems, are mainly in the form of low molecular-weight (LMW) sucrose and high molecular-weight (HMW) sucrose-derived polymers of fructose (fructans). While much information is known about the distribution of WSC and their function during the vegetative growth of grasses, the mobilisation of WSC from vegetative organs to the seed during reproductive development is less well understood.

This update reports on research to identify if the total amount of plant carbohydrate is limiting seed yield, and the contribution of vegetative and reproductive tissues to final seed yield. The pattern of water-soluble carbohydrates' (WSC) accumulation and remobilisation was also investigated. All of this work was carried out in field-grown perennial ryegrass plots.

**Method**

Tillers were sampled from early head emergence through to harvest and the amounts of water-soluble carbohydrates (WSC) in leaf blades, leaf sheaths, internodes and reproductive heads of the tillers were measured in two ways. Firstly, WSC were estimated indirectly by changes in tissue dry weight. These changes were then used to determine any apparent translocation of WSC from vegetative tissues to the developing seed. Secondly, WSC concentration was measured directly. Low molecular weight (LMW) and high molecular weight (HMW) WSC were extracted from vegetative and reproductive tissues and the concentrations quantified.

**Results**

All trial work was undertaken in fields where greater than 2500 kg/ha seed was harvested by the host farmer.

**Changes in dry weight**

Overall, as seed filling occurred the leaves got lighter, suggesting an export of carbohydrate to either the stem and/or seed head. (Figure 1). At all growth stages, the newer leaves (leaf sheath and blades) were heavier than the older leaves. For example, the leaf sheath of the flag leaf was significantly heavier than the other individual leaf sheaths, possibly because carbohydrate had been transported out of the older leaves and into the internodes.

In contrast there was a large overall increase in the dry weight of the internodes over the same period where, 31% of the final internode weight was accumulated during seed fill. The dry weights of the heads increased during seed fill from 99 mg per tiller (early head emergence) to 329 mg per tiller at the end of seed fill. The simultaneous increase in stem and head weight suggests that total carbohydrate supply does not limit seed production.
Carbohydrate concentration and distribution

The total water-soluble carbohydrates (WSC) concentration changed significantly in the different plant parts from early head emergence through to harvest (Figure 2). In leaf blades and leaf sheaths, total WSC steadily declined throughout reproductive development, in a similar way to dry weight, as presented above. In heads, WSC decreased from early head emergence to full head emergence, increased during seed fill and decreased again from mid seed fill to harvest. In contrast to the leaf blades, leaf sheaths and heads, total WSC in the stem internodes increased from early head emergence through to mid seed fill and remained high through to harvest.

Concentrations of high molecular weight (HMW) WSC (the storage type) in individual internodes increased substantially during reproductive development (Figure 3a) with the majority of HMW WSC accumulating in the two most basal internodes (internodes three and four below the head). Proportionality there were much less mobile WSC (LMW) with a trend for these to reduce in all internodes following head emergence (Figure 3b).

Conclusions

The results of this study suggest that the total amount of water soluble carbohydrates (WSC) in vegetative tissues following anthesis is not limiting seed yield. While the total amount of WSC supply per tiller may not be limiting seed yield, the distribution and remobilisation of the WSC to developing seed may be an important factor limiting seed yield. This is due to the majority of the carbohydrate being of storage form and not able to be transferred to the seed head.

During seed fill there was a simultaneous gain in dry weight and WSC in the internodes and seedheads. This suggests that perennial ryegrass has the capacity to fill seed and accumulate storage WSC in the stems. This is potentially due to the persistant nature of perennial ryegrass where it requires carbohydrate to regrow in the following autumn. If the amount of WSC in the stem could be altered with more redistribution of carbohydrates to the seed head then advances in seed yield may be possible.

The present study indicates that the seed head itself may be an important factor driving seed fill. The decrease in dry weight and low levels of WSC in leaf blades and leaf sheaths, combined with the increase in dry weight and WSC of internodes, suggests the seed head has sufficient capacity to fill seeds without large contributions from the vegetative tissue. Further research is required to determine if management techniques can alter the proportions of mobile to storage WSC which may lead to advances in seed production.

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