Performance Indicators for Harvest Timing of Whole Crop Cereals for Silage

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Abstract

Cereals harvested at the soft to medium dough stage provides energy supplement for dairy and beef feeding whenever pasture feed shortages occur. These crops are a lower risk option than maize in the more southern latitudes of New Zealand. The decision to harvest for silage is a compromise between increasing yield and decreasing quality within a narrow harvest date opportunity.

Methods for assessing herbage quality and yield are important for ensuring a nutritionally balanced product and maximising productivity. Test crops of barley, wheat, triticale and oats were at established at Lincoln, New Zealand to determine the scale of crop quality, biomass and moisture content changes during grain filling.

Relationships are shown for biomass yield and quality, and the progress of DM% and herbage quality changes during maturation. The value of herbage, calculated on composite yield and quality criteria proved suitable for discriminating between cultivars. Dry matter change was primarily driven by thermal time after awn tip appearance and a model was derived for predicting crop maturation of each cultivar in trials.

Media summary

Assessment methods based on changes in quality, yield and dry matter content were developed for optimising harvest timing of whole crop cereal silage in New Zealand.

Key Words

Whole crop silage, crop quality, harvest timing, silage, supplementary feeds

Introduction

Timing of silage harvest is the single most important factor affecting the yield and quality of whole crop cereals (WCC) used for conserved feed. While the metabolisable energy value is often marginally lower than maize, WCC do provide animals with a valuable source of fibre to enhance rumen function (Kolver 2000). Herbage quality and yield can potentially be managed through crop selection and crop breeding. However, crop management options such as sowing date, fertiliser, irrigation and variable weather also influence crop growth and maturation. Yield advantage may be gained by extended green leaf area durations (Gallagher and Biscoe, 1978; Kiniry et al. 1979) through crop management or cultivar selection. Ear moisture, ear fresh weight (FW), ear dry weight (DW) and leaf fractions are indicator variables that growers could use in place of destructive sampling for DM% content and therefore assist with decision making close to harvest. The ensilability of cereal herbage is also dependent on the dry matter content (DM%) at harvest and the concentration of readily fermentable sugars in the herbage.

Monitoring procedures require development so that growers and contractors can maximise the productivity and minimise the decline in herbage quality to ensure the appropriate water content for silage fermentation. The variation in moisture content occurring within paddocks and during the course of harvest means that inaccurate calculations are often made of total yield and the quality is not optimised. The changes in (DM%) of whole crop cereals and relationships to maturation are shown for experiments over three seasons.

Methods

Cultivar, nitrogen fertiliser and irrigation trials were established at Lincoln, New Zealand (Lat. 43?39'S; Long. 173?30'E). All trials were arranged in RCBD designs for comparing yield and dry matter (DM%) development of wheat, barley, triticale and oats cultivars.

Cultivars and growing conditions for spring-sown forage cereals were documented by de Ruiter et al. (2002) Sowing rates ranged from 150 to 180 kg/ha were adjusted for each cultivar to achieve a consistent plant population of 250-300 plants/m^2 in 9-row plots (12 m x 1.5 m) and 15 cm row spacing. Methods for biomass yield, dry matter content and quality determinations were described by de Ruiter et al. (2002). Indices for were calculated for 1) relative yield (YLD), defined as actual yield (t/ha)/20; (2) Relative quality (QUAL) comprising equal relative weighting of protein/12, total carbohydrate/25, neutral detergent fibre/40 and digestibility/75; (3) IYQ - equal relative weighting of YLD and QUAL; 3) combined protein and carbohydrate composition index (IPr + ICHO) and 4) ratio of protein to carbohydrate (PCRatio), for sequential harvests from flowering to grain maturity.

Results

Crop Yield and Dry Matter Content

In all trials, the maximum biomass for silage did not align with the optimum DM% content (38%) for silage making. Therefore, decisions to harvest crops for silage resulted in a compromise between yield loss from early harvest or lowered ensilability by harvesting later at lower moisture content.

The response to nitrogen fertiliser was greater in triticale than in wheat with up to a 4 t/ha additional biomass produced with high rates of nitrogen (Figure 1). However, there was only a small influence of nitrogen fertiliser on the progress of crop dry down (data not shown). Similarly, there were only small differences in the rate of crop dry down when comparing irrigated with dryland crops (Figure 2). The experiment was conducted in a wet year and therefore the scale of response was expected to be small although differences in measured soil water content between irrigated and non irrigated treatments were significant.

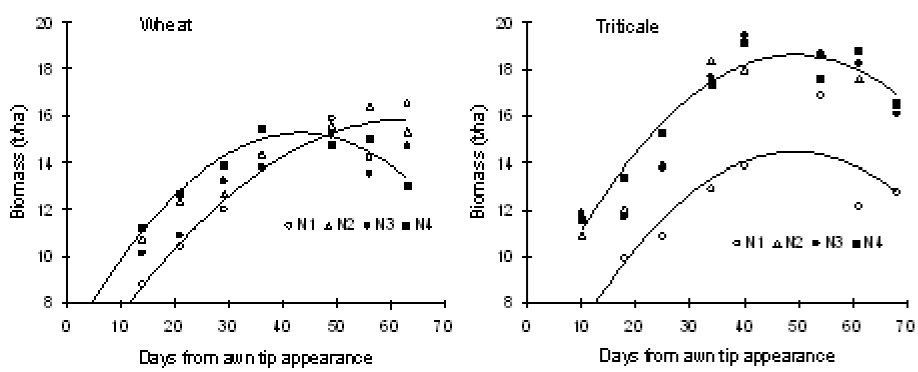

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Figure 1. Progress of biomass during grain fill for wheat and triticale grown under four nitrogen fertiliser treatments. Solid lines indicate quadratic fits to respective nil (N1) and high (N4, 250 kg/ha) N treatments.

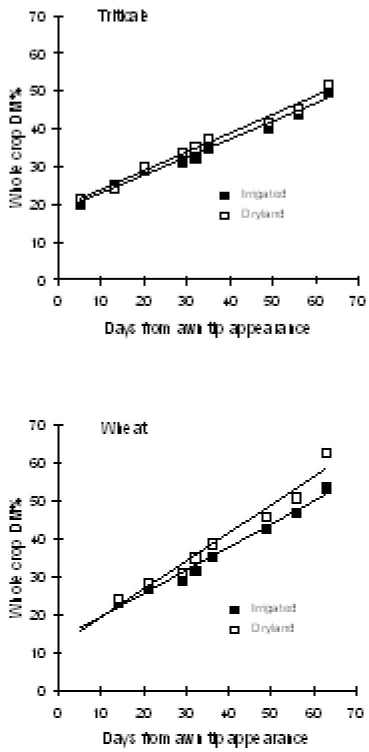

Figure 2. Effect of irrigation on progress of whole crop dry matter (DM%).

Ideally, for predictive purposes, the change in DM% content for individual cultivars should apply to all management options, growth conditions and soil types. It would be reasonable to assume that a single response apply to all situations if DM% change was solely driven by aerial environmental variables rather than soil factors such as water and N availability.

Variables for monitoring progress toward maturity

In all treatment combinations, there was a progressive decline in green leaf area and leaf to stem ratio along with increasing senescence of stems, increasing ear weight, and loss of ear moisture.

Leaf senescence

There was a significant delay in senescence in the irrigated treatments. Moreover, relationships with leaf proportion were species and cultivar specific. Similarly, high N treatments caused delayed leaf senescence for equivalent stages of whole crop dry down. Typically, all species had at least 5% green leaf (by weight) when the whole crop dry passed through the 40% DM stage.

Dry matter content of ears

An alternative to sampling of WCC for DM% was to sub-sample ears only and then predict whole crop DM% ear dry matter content. However, unstable relationships with whole crop DM% also occurred. Deviation in the relationship was due more to the nitrogen than irrigation treatments. Variation in ear weights as a result of N treatment was possibly due to uncoupling of ear development with whole crop DM%. Treatments with high N application had larger ears with lower DM% content than corresponding ears in the lower N treatments.

Differences between moisture content of ears and whole crop in the respective irrigation treatments were compounded by differences in the species responses. In wheat, there was a more complex relationship described by a log function with small differences explained by irrigation effects. The drying patterns were described satisfactorily by a single universal linear equation in barley and triticale with a linear relationship between the variables and only minor separation between the irrigated and non irrigated treatments.

Prediction of DM % using thermal time

In the period from awn tip appearance (GS49) to silage maturity the dry down pattern was close to linear in relation to thermal time (Figure 3). It was assumed that temperature and radiation were the key drivers of plant growth and development although deviations from predicted dry down may occur in response to variable weather influences such as prolonged period with low humidity or periods of high humidity before harvest. The development rates for barley and wheat are similar while triticale was significantly slower to mature.

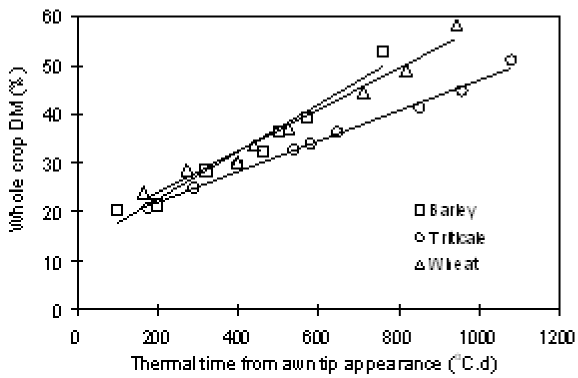

Figure 3. Response of whole crop dry matter to thermal time (base 0?C) accumulation after GS 49 (Zadoks et al. 1974)

A standard procedure was defined for predicting harvest timing. This was based on a known thermal time duration from GS49 to maturity for each cultivar tested. Thermal time was monitored in test crops for a 15 day period after GS49 and the date of harvest predicted on the assumption that daily accumulation of thermal time was unchanged until maturity. Final harvest date prediction was made on the basis of the crop achieving a DM% content of 38%. The predicted duration from flowering to ideal harvest DM% varied from 20 to 35 days depending on the cultivar, crop management and weather conditions. Predicted harvest dates were within 2 days of the observed dates for crops attaining 38% DM.

Indices for cultivar performance

Primary indicators for herbage quality comprise protein, total soluble carbohydrate (soluble sugars + starch)

and metabolisable energy. Yield and quality attributes were integrated by calculating index values based on composite yield and quality (IYQ) performance criteria. A yield optimum of 20 t/ha was chosen for comparing relative cultivar performance. Values of the IYQ > 0.8 indicated good overall performance. Values in excess of 0.8 rarely occurred before final harvest (taken at 38 % DM). The combined index for protein and carbohydrate (IPr+ICHO) showed that quality improved with advancing maturity, despite decreasing protein content. Values > 0.8 for IPr+ICHO occurred from the mid-grain filling stage. An acceptable index value for this variable occurred earlier in grain filling than for IYQ. The protein carbohydrate ratio (PCRatio) declined consistently as the crops matured. Acceptable quality on the basis of this index only occurred in samples taken shortly after flowering when the post-flowering protein content was highest.

With progress of grain filling, the carbohydrate composition steadily increased, as shown for barley while protein declined. Requirements for high yield need to be balanced with the expected reduction in fibre quality and digestibility as the crops approach physiological maturity. Early harvest will offset the gains that are likely from improved yield and energy content achieved through grain growth.

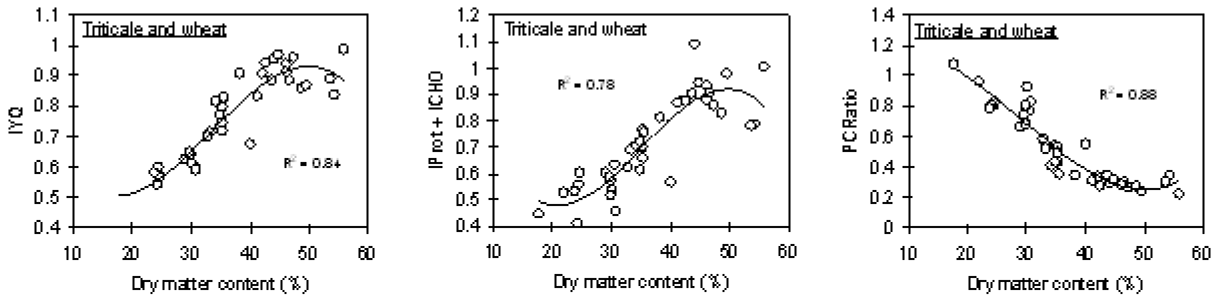

Figure 4. Mean change in DM content for whole crop cereal silage after flowering. Observations for each cultivar were derived from trials 2 and 3 over two seasons at Lincoln. Fitted curves are the mean cultivar responses for cultivar groupings.

Conclusions

- Dry matter content was the best indicator for crops approaching silage maturity. Other indicators (ear DW, ear FW, Ear DM%) were not considered rigorous enough for use in the field.
- Dry matter content change in silage crops was predicted well using daily mean temperature (base 0?C) accumulation and this formed the basis for a harvest date prediction tool.
- Indices generated from quality variables and combined yield and quality criteria gave good descriptions of suitability of herbage for silage harvest and was related strongly to the dry matter (DM%) content.

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