ALTERNATIVE FORAGES TO GRASS FOR ENSILAGE AND AS FEEDS FOR BEEF CATTLE

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Summary: The relative economic attractiveness of crops for ensilage depends on their yield and composition, the efficiency of conservation and factors relating to costs. The nutritive value of forage cereals depends on grain development, the ratio of grain to stover/straw, and the quality of the stover/straw. Co-ensiling leaf and root components of fodder beet produces a feedstuff of excellent nutritive value. Red clover can produce high yields of excellent quality, but needs to remain productive for several years. High-moisture grain technologies permit livestock farmers conserve and feed grain using lower cost resources.

Key words: whole-crop cereal, forage maize, fodder beet, red clover, high-moisture grain

INTRODUCTION

Beef and dairy production systems in Ireland are based on cattle grazing grass for about eight months of the year, with grass silage being the main source of forage during the winter. Additionally, grass silage facilitates grazing management, permits efficient and hygienic recycling of animal manures and can be used to help reduce the internal parasite challenge to grazing cattle. High yields of good quality grass ensiled with minimal losses and produced/conserved/fed with restrained input costs are therefore essential in order to provide cattle with an economically attractive feedstuff during winter and to support sustainable systems on most farms.

However, the relatively modest yields achieved in a single harvest allied to variability in digestibility and ensilability (and thus in intake and animal performance response) and the likelihood of effluent production can create disadvantages for grass silage compared to some alternative forage crops. Thus, alternative forages are being considered on many farms. Their function is to improve farm profits and not simply to increase intake or levels of animal production. Consequently, consideration of the role for these alternative forages needs to encompass factors such as relative total costs of production, relative revenues from the sale of meat or milk, relative payments of income supports and ultimately farm profits.

Crops for which summaries of Irish research results will be presented in this paper include whole-crop (small grain) cereal silage, forage maize, whole-crop fodder beet silage and red clover. In addition, recent research on high-moisture grains will be summarised.
WHOLE-CROP (small grain) CEREAL SILAGE

When grown for whole-crop silage production, the target yields for small-grain cereal crops such as wheat, barley, triticale, oats or rye are those relevant to crops produced for commercial grain production. Thus, if yields of 8 and 6 t grain dry matter (DM)/ha are achievable with winter wheat and spring barley, respectively, and with a target of half of the harvested crop DM being present in the grain (remainder in straw + chaff), then corresponding whole-crop yields of 16 and 12 t DM/ha are achievable. The quality of these whole-crop cereals depends on grain development, the ratio of grain to straw (+chaff), the quality of the straw and chaff, and the effectiveness of the conservation process employed.

Cereals grown for whole-crop silage are normally grown in monoculture (i.e. not sown in binary mixture with a legume or undersown with grass) and are harvested at a later growth stage than when harvested for arable silage. Their relatively high DM concentration prevents effluent production and ensures that preservation will be straightforward.

Harvesting the whole-crop should not take place until after the grain component has progressed beyond the milky-ripe growth stage - until the grain has at least reached the soft-cheddar consistency (i.e. whole-crop at > 350 gDM/kg) (O'Kiely & Moloney, 1995a). The whole-crop nutritive value is effectively constant while the grain progresses from the “soft-cheddar” stage through to hard-cheddar consistency (whole-crop at approx. 550 gDM/kg) (O'Kiely & Moloney, 1999a; O'Kiely & Moloney, 2002). No consistent benefit (and sometimes disadvantages) accrues from treating such a crop with urea (i.e. using conventional technologies). The attractions of urea are that it increases crop crude protein content, restricts mould growth at feedout and has the potential to upgrade fibrous feed (alkali effect). If used, it should be applied only to crops above 500 gDM/kg. If urea is applied to crops of 400 gDM/kg, intake and animal performance may well be reduced (possibly severely) (O'Kiely & Moloney, 1995a; O'Kiely & Moloney, 1999a).

The nutritive value of whole-crop cereal silage for beef cattle can range from being inferior (O'Kiely & Moloney, 1999a) to being superior (O'Kiely & Moloney, 2002) to good grass silage, with the difference in nutritive value relativity being predominantly determined by the content of developed grain and the digestibility of the straw + chaff. The proportion of grain in the crop will have a major bearing on whole-crop nutritive value, and higher grain yields and/or lower yields of harvested straw can influence this. Excellent whole-crop cereal silage can have a nutritive value very similar to maize silage, but probably with a somewhat inferior feed conversion efficiency (Walsh et al., 2005; Walsh et al., 2006). Furthermore, contrasting crops such as winter wheat and spring barley, both with 0.5 of the harvested DM present in grain, can have a similar (and excellent) nutritive value (Walsh et al., 2006).

It could be speculated that allowing the crop ripen so that crop DM concentrations increase above 600 gDM/kg would allow grain nutritive value to increase. However, this would produce grains that, if not processed, would be more likely to pass through the animal undigested (thereby significantly reducing effective nutritive value). Furthermore, the straw component of this more mature crop would likely have diminished digestibility (further decreasing nutritive value). Such a crop should benefit from its grain being processed, with an
accompanying urea+urease treatment increasing the overall concentration of crude protein, inhibiting potential mould activity and possibly making some contribution to upgrading the fibre fraction of the harvested crop. The comparison of ‘Fermented’ and ‘Alkalage’ whole-crop wheat presented by Walsh et al., (2005) involved a crop being cut to the same stubble height when it was at 400 gDM/kg and again three weeks later when at 710 gDM/kg. The later harvested grain was processed at harvesting and the crop treated with a urea-based additive. The results in Table 1 show a relatively similar nutritive value for the ‘Fermented’ and the ‘Alkalage’ whole-crop wheat when offered to finishing beef steers.

Table 1. Feed DM intake, growth, kill-out proportion and feed conversion efficiency (FCE) for grass, maize and whole-crop wheat (WCW) based diets

<table>
<thead>
<tr>
<th></th>
<th>Grass silage</th>
<th>Maize silage</th>
<th>Fermented WCW</th>
<th>Alkalage WCW</th>
<th>Ad libitum concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage DM intake (kg/d)</td>
<td>4.54</td>
<td>6.75</td>
<td>7.07</td>
<td>7.56</td>
<td>0.95</td>
</tr>
<tr>
<td>Total DM intake (kg/d)</td>
<td>7.07</td>
<td>9.27</td>
<td>9.59</td>
<td>10.06</td>
<td>9.86</td>
</tr>
<tr>
<td>Liveweight gain (g/d)</td>
<td>802</td>
<td>1200</td>
<td>1149</td>
<td>1132</td>
<td>1502</td>
</tr>
<tr>
<td>Carcass gain (g/d)</td>
<td>479</td>
<td>776</td>
<td>723</td>
<td>686</td>
<td>851</td>
</tr>
<tr>
<td>Carcass weight (kg)</td>
<td>290</td>
<td>335</td>
<td>329</td>
<td>321</td>
<td>348</td>
</tr>
<tr>
<td>Kill-out (g/kg)</td>
<td>523</td>
<td>547</td>
<td>539</td>
<td>532</td>
<td>551</td>
</tr>
<tr>
<td>FCE (kg DM intake/kg carcass gain)</td>
<td>15.2</td>
<td>12.1</td>
<td>13.5</td>
<td>14.8</td>
<td>11.9</td>
</tr>
</tbody>
</table>

Unwilted grass silage DMD = 674 g/kg; Continental X steers with starting liveweight of 424 kg offered 3 kg concentrates per head daily for 160 days

Raising the cutting height of a crop (i.e. higher stubble) should shift the balance between grain and straw+chaff towards grain, thereby increasing silage nutritive value. However, in an experiment (Walsh et al., 2006; Table 2) where the cutting height of winter wheat (67 cm plant height) was 12 (WCW) or 29 (HCW) cm and of spring barley (71 cm plant height) was 13 (WCB) or 30 (HCB) cm, there was no significant impact on animal productivity of elevating cutting height - presumably in these cases cutting height needed to be elevated further before a significant response could be measured.

Table 2. Feed DM intake, growth, kill-out proportion and feed conversion efficiency (FCE) for maize and whole-crop cereal silages

<table>
<thead>
<tr>
<th></th>
<th>Maize silage</th>
<th>Fermented WCW</th>
<th>Fermented HCW</th>
<th>Fermented WCB</th>
<th>Fermented HCB</th>
<th>Ad libitum concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage DM intake (kg/d)</td>
<td>6.58</td>
<td>7.22</td>
<td>7.08</td>
<td>7.21</td>
<td>6.82</td>
<td>1.29</td>
</tr>
<tr>
<td>Total DM intake (kg/d)</td>
<td>9.21</td>
<td>9.84</td>
<td>9.71</td>
<td>9.84</td>
<td>9.44</td>
<td>9.51</td>
</tr>
<tr>
<td>Liveweight gain (g/d)</td>
<td>1235</td>
<td>1254</td>
<td>1237</td>
<td>1151</td>
<td>1208</td>
<td>1473</td>
</tr>
<tr>
<td>Carcass gain (g/d)</td>
<td>781</td>
<td>741</td>
<td>758</td>
<td>736</td>
<td>780</td>
<td>939</td>
</tr>
<tr>
<td>Carcass weight (kg)</td>
<td>344</td>
<td>338</td>
<td>341</td>
<td>337</td>
<td>344</td>
<td>366</td>
</tr>
<tr>
<td>Kill out (g/kg)</td>
<td>541</td>
<td>529</td>
<td>535</td>
<td>541</td>
<td>545</td>
<td>549</td>
</tr>
<tr>
<td>FCE¹</td>
<td>12.0</td>
<td>13.5</td>
<td>13.1</td>
<td>13.6</td>
<td>12.4</td>
<td>10.3</td>
</tr>
</tbody>
</table>

¹ 1 kg DM intake / kg carcass gain; WCW = whole-crop wheat; HCW = head-cut wheat; WCB = whole-crop barley; HCB = head-cut barley; Continental X steers with starting liveweight of 438 kg offered 3 kg concentrates per head daily for 160 days.

Source: Walsh et al. (2005)
Diets based on *ad libitum* access to fermented whole-crop cereal silage supplemented with 3 kg concentrates daily supported live- and carcass-weight gains by cattle that were 0.82–0.88 and 0.79–0.81, respectively, of diets based on *ad libitum* concentrates (+1 kg forage DM daily), and with total DM intakes at 0.97–1.03 of the high-concentrate diet (Tables 1 & 2).

Thus, whole-crop wheat or barley silages should ideally be produced from crops that are between 400 - 450 gDM/kg. The target is to have approximately half of the DM for a crop (harvested to a 12 cm stubble) present in the grain, giving in excess of 200 g starch/kg crop DM. Conservation losses should be limited to a DM target of 120 g/kg harvested, producing aerobically stable silage with negligible mould presence.

The data of O’Kiely & Moloney (2002) suggest that a synergistic benefit can be obtained by cattle offered a mixture of grass + whole-crop cereal silages relative to the average of animals offered grass silage or whole-crop cereal silage alone.

Moloney et al. (2002) indicated that, relative to grass, whole-crop (small grain) cereal silage produced a whiter carcass fat but a similar colour for lean tissue when all silage types were compared under similar conditions. Each silage had similar direct effects on meat toughness when compared at similar carcass weight.

**MAIZE SILAGE**

The nutritive value of forage maize silage is driven mainly by its content of starch, and thus of grain. Good quality crops will have half of their harvested DM contributed by well-filled cobs (i.e. grain + rachis) with the remainder coming from the stover. Thus, the target harvested whole-crop DM concentration would be 300 gDM/kg with a corresponding starch concentration above 250 g/kgDM. The cobs themselves should have reached 500 g DM/kg. Since the stover accounts for half of the harvested DM, its quality is also important - a major decline in stover digestibility (DMD) can occur as the crop matures (Little et al. 2005), so it is important to balance achieving optimal yield and cob development with avoiding delaying harvesting until stover digestibility has declined excessively.

Maize can be sown beneath a mulch of clear, plastic sheeting. Under circumstances where accumulated ambient temperatures throughout the growing season are inadequate to support the optimal development of maize, the rise in soil temperatures beneath the mulch supports the more rapid germination and establishment of maize plants, and results in higher DM yields of higher starch content being achieved (Easson & Fearnehough, 2003; Keane et al., 2003).

The nutritive value of forage maize for beef cattle ranges from being inferior (O’Kiely & Moloney, 1995b) to being superior (O’Kiely & Moloney, 2000) to good grass silage. Thus, highly digestible maize silage of high grain (i.e. starch) content can support rates of carcass gain by beef cattle that are superior to what are achieved with good grass silage, but with a somewhat lower efficiency of converting ingested forage DM to carcass. Similarly, diets based on *ad libitum* access to maize silage supplemented with 3 kg concentrates daily supported live- and carcass-weight gains by cattle that were 0.84–0.86 and 0.83–0.91, respectively, of diets based on *ad libitum* concentrates (+1 kg forage DM daily), and with total
DM intakes at 0.94-0.97 of the high-concentrate diet (Walsh et al., 2005; Walsh et al., 2006).

The data in Tables 1 and 2 do not indicate that a significant synergistic benefit is necessarily obtained by cattle offered a mixture of grass + maize silages relative to the average of animals offered grass silage or maize silage alone.

Moloney et al. (1999) indicated that, relative to grass silage, maize silage produced a whiter carcass fat but a similar colour for lean tissue when both silage types were compared under similar conditions. Both silages had similar direct effects on meat toughness when compared at similar carcass weight.

**WHOLE-CROP FODDER BEET SILAGE**

Fodder beet roots and leaves have a high nutritive value, and data have previously been published on the nutritive value of each of these. Both leaves and roots can be ensiled together to produce a silage of high nutritive value (O'Kiely & Moloney, 1999b) - thus, the whole-crop fodder beet silage based diet supported a carcass gain that was 0.89 that of the animals on ad libitum concentrates (albeit with a 0.18 poorer feed DM conversion efficiency). Whole-crop fodder beet can produce large volumes of relatively high quality (i.e. energy) effluent when ensiled, but this can be largely retained within the silo by using sufficient absorbent (O'Kiely & Moloney, 1999b). Thus, when dry beet pulp nuts were ensiled with whole-crop fodder beet at 159 kg/tonne, effluent output declined from 419 to 122 l/tonne while carcass gain was not altered (O'Kiely et al., 1993).

**RED CLOVER**

Red clover is considered a short-lived perennial legume that can be highly productive for two to three years, and whose upright growth habit makes it particularly suited for hay and silage making. Under circumstances where permanent grassland dominates ruminant systems, the important target for red clover is to greatly improve its persistence and thus its potential contribution to feed supply.

An ongoing experiment at Grange is quantifying the impacts of cultivar, companion grass, harvest schedule and nitrogen (N) fertiliser on crop yield and digestibility over several years. Two cultivars (Merviot and Ruttinova) were sown in monoculture (15 kg seed/ha) or in a binary mixture with perennial ryegrass (cv. Greengold) (10 kg red clover + 10 kg perennial ryegrass seed/ha) in August, 2001. They received 0 or 50 kg inorganic N fertiliser per ha each March and had a first-cut harvest date of late May or mid-June. Sequential harvests followed each first cut, with a total of four harvests per system completed by early December. Simultaneously, monoculture plots of perennial ryegrass (cv. Greengold; 30 kg seed/ha) received 0, 50, 100 or 150 kg inorganic N/ha in mid-March and immediately after the first three harvests, with similar harvest dates to the red clover.

After five seasons since reseeding, red clover still dominates some treatments while in others it has long disappeared. Thus, factors favouring the persistence of red clover include no application of inorganic N in March and a first-cut harvest date in late May rather than mid-June. Furthermore, the binary mixture with grass resulted in an improved annual yield and digestibility compared to sowing red clover as a monoculture.
In the first year after reseeding, the red clover + grass swards that received no inorganic N fertiliser and had a first-cut harvest date in late May, had an annual DM yield (13.2 t/ha) that was 1.36 and 0.86 of perennial ryegrass monocultures that received an annual input of inorganic N fertiliser of 0 and 360 kg N/ha, respectively (O’Kiely et al., 2006a). The corresponding values in the third year (16.4 tonnes DM/ha) were 1.67 and 0.95 (O’Kiely et al., 2006b).

**HIGH-MOISTURE GRAIN**

Cereal grains of less than 140 g moisture per kg can be safely stored for an extended duration. As grain moisture content rises the duration of safe storage becomes shorter and the requirement for aeration initially and then for drying or other preservation treatment progressively increases. Alternative technologies facilitate successfully conserving grain harvested at up to greater than 400 g moisture/kg.

One important issue when considering the conservation of high-moisture grain is how does the stage of ripening at harvest influence grain yield and quality. During two seasons, crops of winter wheat, barley and triticale were grown and grain was harvested at a series of stages from above 400 g moisture/kg to under 200 g moisture/kg. For each cereal, the fresh yield of grain declined with advancing ripening, reflecting the disappearance of water from the mature grain as it dried (Stacey et al., 2007a). However, the yield of grain DM was quite constant across the growth stages investigated. Physiological maturity is the point at which grains reach their maximum dry weight, so clearly each of the crops had reached physiological maturity prior to the commencement of the study.

The ripening process from above 400 g moisture/kg grain to below 200 g moisture/kg grain took from 10 to 22 days, depending on the crop and on prevailing weather conditions. Thus, daily drying rates involved a decrease of 9 to 29 g moisture/kg. In addition, grain drying rates also varied within individual days. This means that frequent monitoring of grain moisture content is required if farmers wish to harvest at a target moisture content, and the duration for which this target moisture content is maintained can be relatively short.

In general, measurements of grain nutritive value such as digestibility, starch, protein and ash were relatively constant during the ripening process. Measurements of ensilability, including sugar content and buffering capacity, indicated that the various moist grains investigated were likely to preserve satisfactorily if they were ensiled (e.g. crimped grain).

To quantify the feeding value of high moisture and conventionally conserved grains, continental crossbred steers were offered a low digestibility grass silage alone or with wheat-based concentrates at the equivalent (standardised for moisture content) of 3 (low) or 6 (medium) kg/head/day, or ad libitum, for 144 days. Wheat had been either:

(a) harvested at 300 g moisture/kg, crimped (i.e. rolled), treated with a mixture of organic acids and ensiled (‘Crimped & ensiled’).

(b) harvested at 260 g moisture/kg, treated with urea solution and stored under plastic sheeting. This was offered whole (i.e. unrolled) (‘Urea-whole’).

(c) harvested at 160 g moisture/kg, treated with propionic acid and rolled before feeding. This was considered the ‘Conventional’ or reference treatment.
The 'Crimped & ensiled', 'Urea-whole' and 'Con ventional’ wheat had pH values of 4.3, 9.3 and 4.8, respectively, and corresponding crude protein values of 116, 145 and 111 g/kg DM. Stacey et al. (2007b; Table 3) indicate that 'Crimped & ensiled' wheat grain could replace 'Con ventional’ grain in the ration of finishing cattle without compromising performance or meat colour, provided conservation losses for both forms of wheat were properly restricted. In contrast, The large faecal losses of undigested grains resulted in lower growth rates by cattle offered 'Urea-whole' wheat, and this loss in gain was amplified as it's inclusion rate in the diet increased.

Table 3. Feed intake, growth rate and faecal starch for steers offered alternative forms of conserved wheat grain

<table>
<thead>
<tr>
<th>Grass silage plus</th>
<th>Crimped &amp; ensiled</th>
<th>Urea-whole</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silage intake¹</td>
<td>7.4</td>
<td>5.3</td>
<td>3.7</td>
</tr>
<tr>
<td>Wheat intake¹</td>
<td>0</td>
<td>2.5</td>
<td>4.9</td>
</tr>
<tr>
<td>Liveweight gain²</td>
<td>101</td>
<td>684</td>
<td>887</td>
</tr>
<tr>
<td>Kill-out (g/kg)</td>
<td>484</td>
<td>503</td>
<td>502</td>
</tr>
<tr>
<td>Carcass gain²</td>
<td>64</td>
<td>421</td>
<td>517</td>
</tr>
<tr>
<td>Faecal starch³</td>
<td>8</td>
<td>9</td>
<td>15</td>
</tr>
</tbody>
</table>

Well preserved, unwilted stemmy (DMD 679 g/kg) silage; Friesian steers with mean starting liveweight of 518 kg, offered diets over duration of 144 days. 1kgDM/day 2g/day; 3g/kgDM.

Source: Stacey et al. (2007b)

References


