WINTER OATS: CHANGES IN NUTRITIVE VALUE DURING DEVELOPMENT OF THE CROP

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ABSTRACT

Forage oats (*Avena sativa* L. cv. Florida AB113) were grown at Palmerston North and samples throughout the crop's development were dissected into leaf, stem/sheath and head. Digestibility and crude protein of the crop decreased from 85% to 50% and 31% to 7%, respectively, between the times when leaf sheaths started to lengthen and stems began to form (Feekes scale 4) and flowering (Feekes scale 10.5). The decrease in digestibility was associated with the formation of stem tissue which had a low digestibility (approx. 40%) and made up 70% of total crop weight at flowering.

Nitrogen fertilizer application had no marked effect on the levels of crude protein in the forage.

Additional Key Words: *leaf, stem/sheath, head, crude protein, digestibility, N-fertilizer.*

INTRODUCTION

Considerable attention has been given in recent years to growing oats (*Avena sativa* L.) and other cereals in New Zealand as winter forage crops. Dry matter yields have varied between 5 and 20 tonnes DM/ha depending upon cultivar, time of sowing, time of harvesting, and climate (Kerr and Menalda, 1976; Taylor *et al.,* 1976; Eagles and Taylor, 1976; Eagles *et al.,* 1979; Taylor and Hughes, 1979). In contrast, yields in North America and Britain tend to be lower (Walker, 1959; Smith, 1960; Gardner and Wiggins, 1961; Corrall *et al.,* 1977; Belyea *et al.,* 1978) and rarely exceed 10 tonnes DM/ha.

Analysis of whole plant material from late spring harvests of mature Florida oats (Eagles and Taylor, 1976) showed very low crude protein levels of 6-7%. Eagles *et al* (1979) followed the levels of crude protein and digestibility during the growth of winter oats in the Manawatu and found that the nutritive value of the crop fell markedly after flag leaf emergence. The decline in crude protein especially was more rapid than was the case with oats grown in USA and Canada (Smith, 1960; Gardner and Wiggins, 1961; Kilcher and Troelson, 1973). Eagles *et al.* (1979) postulated that the low crude protein in their crops compared with spring-sown oats in North America could be related to the much higher dry matter yields observed in New Zealand.

Kilcher and Troelsen (1973) investigated the relationship between stage of development of oats and the nutritive value of the major plant components of the crop and concluded that nutritive value could be assessed from the proportion of leaf relative to the whole plant. Similarly, this experiment examines the nutritive changes of plant parts of winter grown oats in the Manawatu. The purpose of this study was to determine why crop digestibility decreases rapidly during the period of maximum dry matter production and whether or not soil nitrogen status influences changes in crude protein during development.

MATERIALS AND METHODS

A sowing date trial (described by Taylor and Hughes, 1979) was carried out on a Tokomaru silt loam at Palmerston North in 1978. *Avena sativa* L. (cv. AB113) was sown at four dates, i.e. 22 March, 13 April, 3 May and 22 May. Another trial was sown on the same soil type on 13 April with four nitrogen fertilizer treatments, i.e. 0, 30, 60 and 120 kg N/ha applied as urea. Half of each urea dressing was applied at sowing, and half at stem elongation. The sowing date trial also had 60 kg N/ha applied as a split dressing. Both trial sites received basal dressing before cultivation of 56 kg P/ha and 112 kg K/ha. Soil pH at the trial sites was 6.2.

Each plot was 2.5 m x 15 m in area and each trial was of randomized block design with four replicates. Yield estimates were taken from 1 m x 1 m sub-plots at intervals of four weeks to produce seasonal forage production curves (reported by Taylor and Hughes, 1979). At each harvest a sample from each plot was dissected into leaf, stem/sheath and seedhead for determination of nitrogen concentration and *in vivo* digestibility. Predicted *in vivo* digestibility was determined on all samples from the 13 April sowing date for eight harvests using the method of Roughan and Holland (1977). The nitrogen concentration of all samples for all sowing dates was obtained by the method of Haslemore and Roughan (1976). Crude protein was determined from N x 6.25.

Data from Eagles *et al.* (1979), who grew Avon, Florida 501, AB113 and Amuri oats in 1977, have also been included in Figs. 4 and 5.

RESULTS AND DISCUSSION

Nutritive value of the oats fell markedly as the plants matured, starting as soon as leaf sheaths commenced lengthening and stems began to form (Figs. 1, 2 and 3). At the boot stage (Feekes scale 9) (Large, 1954), stem/sheath material accounted for approximately 62% of the yield, and increased to a maximum of approximately 70% of the total forage at flowering (Feekes scale 10.5). During the period of maximum rate of dry matter accumulation (Feekes scale 4 — 10.5) stem/sheath material increased very rapidly whereas leaf tissue accumulated relatively slowly and then declined to some extent after the boot stage, probably due to senescence. This resulted in a tall stalky plant when maximum dry matter yield was reached.

The change in nutritive value of different plant parts is shown in Figs. 2 and 3. The digestibility of leaves dropped from 85% (at tillering) to 70% (at flowering) while that of stems dropped from 85% at tillering to 45% at flowering (Fig. 2). The main cause of the overall decrease in digestibility of the crop was the development of stem tissue relative to the rest of the plant (Figs. 1 and 2). Kilcher and Troelsen (1973) found that whole plant lignin levels increased from 35% to 50% of the total plant over the growth period of oats, whereas the stem lignin levels increased from 45% to 70% of the plant. The highly lignified nature of the stem/sheath material probably accounts for the low digestibility of this tissue.

The crude protein concentration as percentage dry matter of the leaves dropped from approximately 32% at tillering to 13% at flowering, with stems dropping from 32% to 3% (Fig. 3).

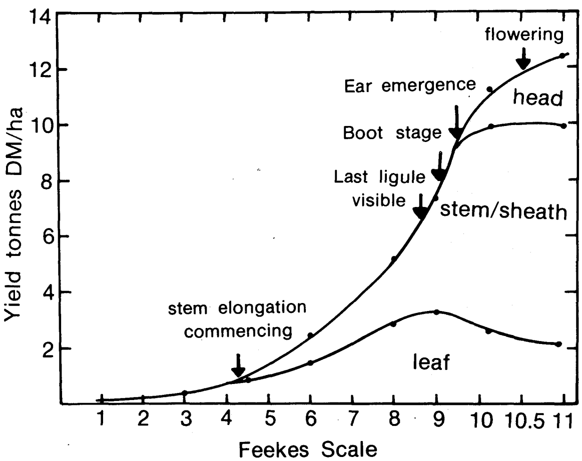

Figure 1: Changes in the proportion of oat plant components with development.

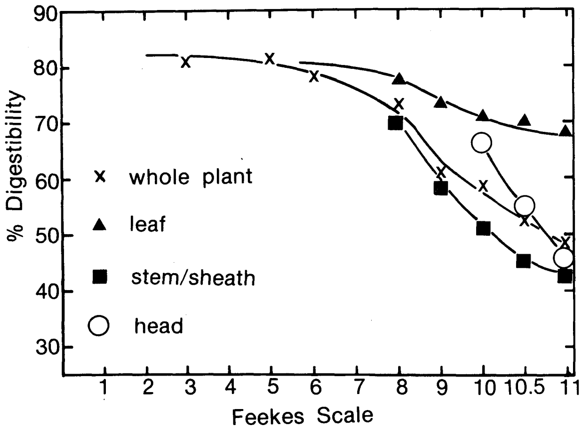

Figure 2: Changes in the digestibility (as %DM) of oat plant components with development (sown 13.4.78).

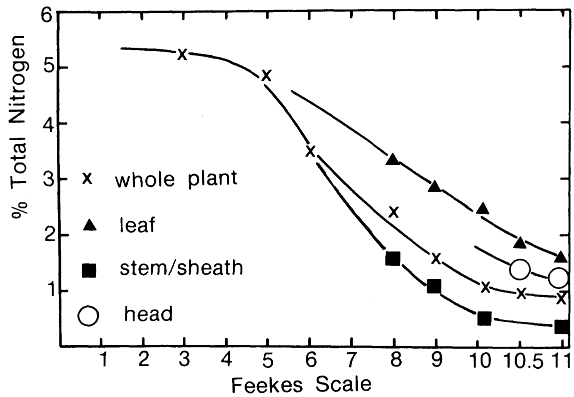

Figure 3: Changes in the nitrogen concentration (as %DM) of oat plant components with development (sown 13.4.78). Crude protein = N% x 6.25.

The overall changes in digestibility and crude protein concentration are shown in Figs. 4 and 5. The data demonstrate that the results obtained in this study are consistent with those obtained in New Zealand by Eagles *et al.* (1979) using four oats cultivars. Both the digestibility and crude protein levels of whole plant oats declined rapidly over the period of development from Feekes scale 3 (early vegetative) to Feekes scale 9 (in boot) resulting in forage of very low quality at the time of maximum dry matter accumulation (Feekes scale 10). If oats are sown in mid-April, Feekes scale 4.5 is reached in approximately 60 days, Feekes scale 9 in 150 days, and Feekes scale 10.5 in 180 days.

A comparison of Canadian data (Kilcher and Troelsen, 1973) with data from this experiment (Table 1) suggests that North American forage oats contain higher protein levels (and implicitly, higher digestibilities) because of a much lower proportion of stem in the forage. The lower yields and higher protein levels usually obtained in North America also support the suggestion by Eagles *et al.* (1979) that high dry matter yields may be incompatible with higher protein concentrations in the forage of New Zealand grown oats.

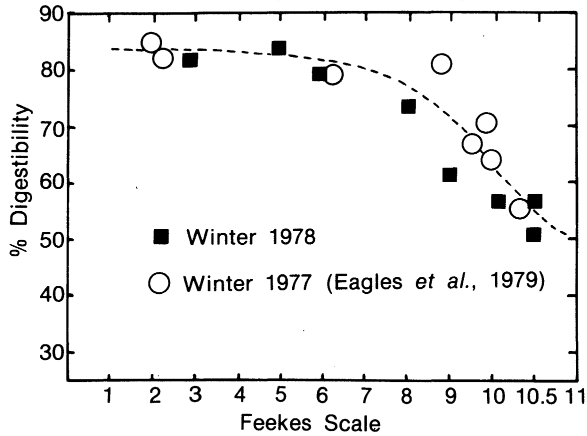

Figure 4: Change in the digestibility (as % DM) of whole plant forage oats with development.

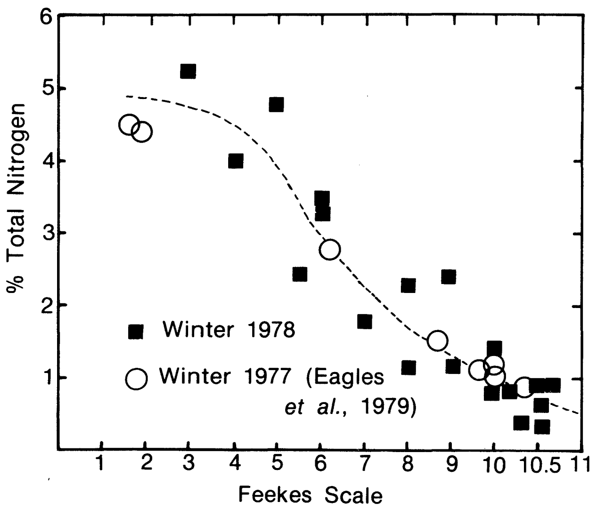

Figure 5: Changes in nitrogen concentration (as %DM) of whole plant forage oats with development. Crude protein = N% x 6.25.

The protein concentration in the plants was not markedly influenced by raising the nitrogen status of the soil (Table 2) despite the small but statistically significant increase shown at higher fertilizer applciations. The yield results indicate that soil available nitrogen was probably not limiting over the experimental period. This suggests that the crude protein levels in the oat forages, both in this study and in the work of Eagles *et al.* (1979), were not limited by lack of available soil nitrogen.

TABLE 1: Oats grown in New Zealand compared with those grown in Canada.[a]

	Canada[b]	New Zealand[b]
Proportion of stem/sheath (% whole plant)	40	62
Whole plant crude protein (%DM)	20	9
Leaf crude protein (%DM)	25	16
Stem crude protein (%DM)	15	6
Yield (tDM/ha)	1.4	8.0

[a] Data from Kilcher and Troelsen (1973).
[b] Both crops in boot (Feekes scale 9).

TABLE 2: Effect of added nitrogen fertilizer on forage nitrogen concentration (percentage of dry matter yield) and yield of AB113 oats grown in the winter 1978 season.

N added	Feeks scale 4		Feekes scale 10.5	
kg/ha	N (%DM)	Yield (tDM/ha)	N (%DM)	Yield (tDM/ha)
0	2.9	0.7	0.9	10.6
30	3.0	0.8	1.0	9.5
60	3.4	0.8	1.1	10.9
120	3.2	0.9	1.2	10.9
LSD 5%	0.4	0.2	0.2	2.5

CONCLUSION

The results indicate that the uninterrupted growth of autumn sown oats in New Zealand results in a tall, stalky plant of very low quality at maturity. This is caused by a rapid accumulation of stem tissue during the period of rapid dry matter production.

In New Zealand, it may be desirable to harvest an oat crop for silage at the boot stage or very soon after to ensure satisfactory nutritive value and animal performance. This is somewhat earlier than recommended by workers in USA, e.g. Smith (1960), Gardner and Wiggins (1961). Low levels of crude protein (9.4% dry matter) in oats at the time of maximum dry matter yield probably make supplementation of protein from other sources necessary to meet animal requirements.

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