

## Research Note

# The Relationship Between Applied Nitrogen, Nitrogen Concentration in Herbage and Seed Yield in Perennial Ryegrass (*Lolium perenne* L.). IV. Cvs. Grasslands Nui and AberElan in the UK

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## ABSTRACT

The relationship between the concentration of nitrogen (N) in herbage in early spring and seed yield of two cultivars of perennial ryegrass (*Lolium perenne* L.), Grasslands Nui and AberElan was tested. Five N treatments (totalling 0, 50, 100, 150 or 200 kg ha<sup>-1</sup>) were applied in various combinations of autumn, late winter and early spring timing to create a range of herbage N concentration in spring. Dry matter was sampled 14 days after spikelet initiation and sent to New Zealand for analysis of combined N. Seed yield and components were analysed at harvest. N resulted in a significant increase in seed yield, herbage N concentration, dry matter yield and N content in both cultivars, but overall yields were extremely low, reflecting moisture stress. A relationship between herbage N % and seed yield was apparent in cv. Grasslands Nui ( $R^2 = 0.58$ ), but was not significant (and so could not be used to predict yield) in cv. AberElan. Critical spring N concentration for 85 % relative seed yield was 2.2 %. Herbage N content was not significantly related to seed yield in either cultivar.

*Additional index words:* cultivar, herbage nitrogen content, seed yield components, seed yield variability, spikelet initiation.

## EXPERIMENTAL AND DISCUSSION

At present there is no legislation on nitrogen (N) use in the United Kingdom (UK). There is, however, considerable concern about the impact on the environment of excessive amounts of nitrogen, particularly where there is a danger of run-off into water courses. Research effort in perennial ryegrass breeding programmes has concentrated on improving the efficiency of nitrogen use during forage production and reducing nitrogen requirement (Wilkins, MacDuff, Raistrick and Collison, 1997). The perennial ryegrass cultivar AberElan was an early cultivar to be released by this programme; 216 tonnes of seed were produced in the UK in 1997 (NIAB, 1997).

This experiment was established to identify differences in nitrogen requirements between cv. Grasslands Nui (which is not produced in the UK but was included as a reference) and cv. AberElan, and to test the model identified for cv. Grasslands Nui under New Zealand conditions (Rowarth and Archie, 1994; 1995) in the UK.

Perennial ryegrass cv. Grasslands Nui and cv. AberElan was drilled on 12.9.95 at 12 kg ha<sup>-1</sup> in 15 cm rows, at the Institute of Grassland and Environmental Research (IGER), Aberystwyth, on soil of the Rheidol series (a permeable, well-drained loam over gravel). Plot size was 3.75 m<sup>2</sup>. Pesticides were applied prophylactically. No irrigation was available at the site; rainfall was measured at IGER. Nitrogen was applied in various combinations (Table 2) on 9.10.95, 1.2.96 and 14.3.96 as a compound fertiliser (21:8:11 NPK).

Fourteen days after spikelet initiation, the herbage was cut just above the leaf sheath from a known area. Herbage was dried overnight at 65 °C, and dry weight recorded, before being sent to New Zealand for analysis (Basson, 1976). Seed was harvested when seed moisture was 40-42 %. After air drying, threshing and cleaning, seed yield and thousand seed weight (TSW) were recorded. Seed yield component analysis

was performed on a subsample of 10 heads per plot. Nitrogen content was calculated from dry matter yield and herbage N concentration 14 days after spikelet initiation. Apparent nitrogen recovery (ANR; %) and nitrogen use efficiency (NUE; kg extra seed per kg applied N) were calculated as described by Rowarth, Boelt, Hampton, Marshall, Rolston, Sicard, Silberstein, Sedcole and Young (1998). Relative seed yield was calculated for each cultivar relative to the maximum seed yield for that cultivar.

Analysis of variance and regression analysis were performed using Minitab. The Cate-Nelson separation technique, which involves partitioning data into diagonally opposite quadrats, was used to establish critical thresholds for response; the more complete the separation, the better the indication of a threshold (Cate and Nelson, 1965).

Rainfall (Table 1) was less than 75 % of the long term mean (LTM) in March and April, 31 % higher in May, and 56 % and 79 % of the LTM in June and July, respectively.

Increasing nitrogen had a significant ( $P < 0.05$ ) and positive effect on seed yield, herbage N (%), dry matter yield and, hence, N content (Table 2) in both cv. Grasslands Nui and cv. AberElan. Overall seed and herbage yields were, however, extremely low (maximum seed yields of 300 kg ha<sup>-1</sup>, which is significantly lower than the yields of c. 1000 kg ha<sup>-1</sup> achieved in commercial practice), reflecting late sowing and moisture stress during the growing season. NUE indicated that applying nitrogen may not have been economic, despite the significant response (Table 2). Reproductive heads in cv. AberElan were significantly increased by increasing nitrogen; no other seed yield components were significantly affected in either cultivar (data not presented). Nitrogen content and apparent nitrogen recovery were also low (Table 2) in comparison with data from similar trials involving cv. Grasslands Nui (Rowarth, *et al.*, 1998). This is thought to reflect the poor dry matter production, as leaf expansion is the major determinant of nitrogen uptake (Grindlay, 1997).

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**Table 1. Rainfall (mm) for the important seed production months in 1996 and the 25 year average.**

	March	April	May	June	July
1996	53.0	43.2	81.2	39.6	63.8
1968-1993	73.9	59.1	62.1	70.7	80.5

**Table 2. Effect of applied nitrogen on seed yield, nitrogen use efficiency, head numbers, herbage nitrogen, dry matter yield, nitrogen content and apparent nitrogen recovery for (a) cv. Grasslands Nui and (b) cv. AberElan**

Nitrogen strategy <sup>1</sup>	Total N (kg ha <sup>-1</sup> )	Seed yield (kg ha <sup>-1</sup> )	NUE <sup>2</sup> (kg seed kg N <sup>-1</sup> )	Heads (m <sup>-2</sup> )	Herbage N <sup>1</sup> (%)	DMY <sup>1</sup> (kg ha <sup>-1</sup> )	N content <sup>1</sup> (kg ha <sup>-1</sup> )	ANR (%)
0-0-0	0	197	-	904	1.88	671	13	-
0-0-50	50	243	0.9	931	2.03	1224	25	25
30-0-70	100	224	0.3	1079	2.20	1307	29	16
30-50-70	150	213	0.1	1098	2.20	1318	29	11
50-70-80	200	300	0.5	1003	2.51	1499	38	19
LSD P<0.05		43.8	na <sup>5</sup>	ns	0.23	153	na	na

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0-0-0	0	221	-	1173	1.92	411	8	-
0-0-50	50	296	1.4	1350	2.16	771	17	18
30-0-70	100	288	0.7	1625	2.30	903	21	13
30-50-70	150	249	0.2	1905	2.24	923	21	9
50-70-80	200	293	0.4	1684	2.39	1294	31	12
LSD P<0.05		35.3	na <sup>5</sup>	331	0.15	77	na	na

<sup>1</sup> Autumn (9.10.95), winter (1.2.96) and spring (14.3.96)

<sup>2</sup> Nitrogen use efficiency

<sup>3</sup> Floret site utilisation

<sup>4</sup> Thousand seed weight

<sup>5</sup> Not available as calculated from means

Regressions fitted to the individual responses for cv. AberElan (data for cv. Grasslands Nui are presented in Rowarth *et al.*, 1998) showed that applied N accounted for 84 and 88 % of the variability in nitrogen concentration and dry matter yield, respectively, 14 days after spikelet initiation (Table 3). No other relationship was significant. In contrast, for cv. Grasslands Nui, herbage N % and dry matter yield were related to applied N ( $R^2 = 0.93$  and  $0.70$ , respectively), and seed yield was related to N % ( $R^2 = 0.58$ ) (Rowarth *et al.*, 1998). However, for both cultivars, 50 kg ha<sup>-1</sup> N applied at spikelet initiation changed the herbage N % by only 0.15 and 0.16 %, respectively, in comparison with 0.45 % in other trials (Rowarth *et al.*, 1998). This provides further evidence, in conjunction with low dry matter yield, low thousand seed weight (1.2-1.7 g) and low ANR, for the major effect of moisture stress. In contrast, floret site utilisation (FSU) was high (65-80 %), reflecting a very low number of florets per spikelet (2.6-4.3) and, possibly, the wet May which resulted in no soil moisture stress during anthesis (peak anthesis was 12th June).

Combining data for both cultivars, 85 % relative yield for the site was obtained with a herbage N % (measured 14 days after spikelet initiation) of 2.2 % (Fig 1). Again this is lower

than results from other sites (Rowarth *et al.*, 1998), probably reflecting the moisture stress. There is no evidence from these data that the cultivars have different N requirements for seed yield. Furthermore, maximum yields were the same for both cultivars. Examination of nitrogen content did not give an improved relationship (data not presented) and the required N content of 25 kg ha<sup>-1</sup> to achieve 85 % relative yield was less than that required in other studies (Rowarth *et al.*, 1998; Sicard and Rowarth, 1998; Young, Silberstein, Chastain and Rowarth, 1998).

Both cultivars responded similarly to the N treatments, but a full response to N was prevented by the late sowing date and soil moisture stress, which decreased dry matter production and hence limited head numbers. A relationship between herbage N % and seed yield was apparent and significant in cv. Grasslands Nui, but was not significant (and so could not be used to predict yield) in cv. AberElan.

These results highlight the difficulty of isolating individual stresses under field conditions, the requirement for irrigation research so that sensitive stages of growth can be identified, and the need for nitrogen requirement models to be sufficiently flexible to make predictions for likely soil moisture scenarios.

Table 3. Regression relationships for cv. AberElan<sup>1</sup>

Regression equations	R <sup>2</sup>	P
Nitrogen concentration = 2.31 + 0.00312 applied N	0.84	0.02
Seed yield = 266 + 0.192 applied N	0.00	0.43
Dry matter yield = 477 + 3.84 applied N	0.88	0.01
Seed yield = 223 + 0.0715 dry matter yield	0.31	0.19
Seed yield = 51 + 89.0 N%	0.35	0.18
Seed yield = 232 + 2.70 N content	0.29	0.20

<sup>1</sup> Data for cv. Grasslands Nui are presented in Rowarth et al. (1998).

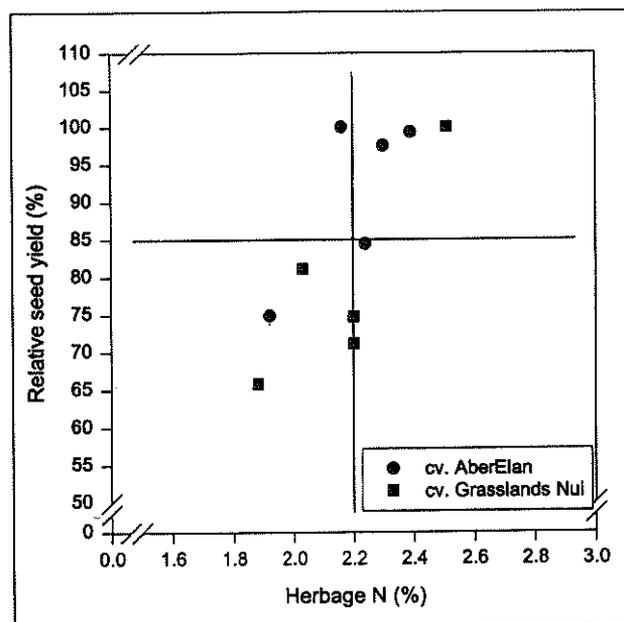


Fig. 1. Relationship between herbage N concentration (%) fourteen days after spikelet initiation and seed yield relative to the maximum yield for cv. Grasslands Nui and AberElan. Cate Nelson separation technique (Cate and Nelson, 1965) is used to show a critical threshold.

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