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Forage Yield and Quality of Barley as Influenced By Nitrogen Application and Harvest Dates

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Abstract

A pot experiment was conducted to study forage yield and quality of barley when harvested at different times (88, 106, 129, 143, 154 and 178 days after sowing) and grown under three nitrogen (0, 50, 100 kg ha^{-1}). Fresh, dry matter and crude protein yields and quality parameters i.e. crude protein percent and modified acid detergent fibre percent were influenced significantly by nitrogen rates and harvest times. Whereas, dry matter percent was only influenced significantly by harvest times. The interaction between harvest times and nitrogen level were also significant for all parameters except for crude protein yield and plant height. Crude protein (CP) percent in whole barley plant decreased with time and remained constant near maturity. Modified acid detergent fibre percent increased with harvest date and reached a maximum at the fourth harvest and then decreased significantly by the fifth harvest. Maximum dry matter (727.7 g) and fresh yields (2184.4 g) were observed at fifth and fourth harvest respectively. The barley fertilized at 100 kg ha^{-1} and harvested 154 days after sowing seems to be optimum combination for getting higher dry matter yield.

Introduction

Among the various agronomic factors that may affect the yield and quality of forage, the application of nitrogen is considered to be the most important (Tofinga, 1990). DiRienzo *et al*. (1991) obtained a linear increase in barley forage yield following the application of 135 kg N ha^{-1}. DiRienzo *et al*. (1987) reported that nitrogen application at the rate of 135 kg ha^{-1} gave higher dry matter yield (8.18 t ha^{-1}) than 0 and 90 kg N ha $^{-1}$. Varvel and Severson (1987) obtained an increase in barley forage yield upto 168 kg ha^{-1}. DiRienzo *et al*. (1986) reported that forage yields were influenced with nitrogen application, but did not differ between the rates of 90 kg N ha and 135 kg N ha^{-1}. Rees *et al*. (1991) obtained an increase of 9 percent in barley forage yield with the application of 30 kg N ha^{-1}.

An increase in the amount of nitrogen results in a greater plant height (Nannetti *et al*., 1990) and leaf area (Ali, 1988) of barley. DiRienzo *et al*. (1991) reported that the crude protein content of barley forage increased as the rate of nitrogen application increased. The greater response was observed when nitrogen was applied at GS 30. The crude protein content of forage ranged from 3.8 percent without nitrogen application to 10.4 percent with 50 kg N ha^{-1} applied at GS 30 and 4.3 percent when nitrogen was applied at GS 25. DiRienzo *et al*. (1991) reported that an increase in nitrogen rate decreased the dry matter percentage of barley forage from 32.3 percent at 0 kg N ha^{-1} to 29.8 percent when 133 kg N ha^{-1} was applied. Zioek and Szmigiel (1982) observed a decrease in the crude fibre content of maize following the application of nitrogen fertilizer. But, DiRienzo *et al*. (1991) reported that nitrogen application did not affect the acid detergent fibre and neutral detergent fibre of barley harvested at the soft dough stage.

Table 1: Mean monthly maximum, minimum and mean temperature and sunshine hours December to May

Months	Maximum temp(°C)	Minimum temp(°C)	Mean temp(°C)	Sunshine hours
December	8.5	3.9	6.2	1.3
January	11.5	4.2	7.9	0.9
February	11.3	3.7	7.5	1.6
March	12.0	5.8	8.9	1.6
April	11.6	4.9	8.3	5.8
May	16.0	9.4	12.9	8.0

Another important factors affecting the quality and yield of forage crops is their growth stage at harvest. Dry matter yield increases when the growth period before harvest is extended, while certain important nutritional characteristics, such as crude protein and digestibility are decreased.

Droushiotis (1984) reported that the dry matter and digestible dry matter yield of several varieties of small grain cereal, increased significantly when harvest was delayed from the booting to the grain milk stage. Papakosta and Gagianas (1991) reported that the protein in the leaf and stern of wheat declined from 20.5 g kg at anthesis to 6.7 g kg^{-1} at maturity. Rodriguez *et al*. (1990) found that crude protein percent in the stalk, leaves and whole millet plants decreased steadily from ear emergence to maturity. He attributed the decreasing protein concentration to a dilution effect as a result of plant growth.

The objective of present study was to assess, under pot conditions, the effect of three nitrogen fertilizer levels on the forage yield and chemical composition of barley. Changes in quality and yield of forage at progressive stages of maturity were also studied.

Table 2: Effect of harvest dates and nitrogen application on the fresh yield of barley (g m^{-2})

Harvest	Days after sowing	Nitrogen rates (kg ha^{-1}) 0	50	100	Means SED ± 90.97
		SED ± 157.56			
H1	88	255.4	972.2	1187.2	804.9
H2	106	483.8	1787.1	2301.9	1524.3
H3	129	568.7	1912.7	2496.4	1659.3
H4	143	852.8	2331.1	3369.3	2184.4
H5	154	760.2	2030.3	2944.6	1911.7
H6	178	583.4	1327.7	1870.5	1245.5
Means SED±64.32		576.5	1726.9	2361.6	

Table 3: Effect of harvest dates and nitrogen application on the dry matter yield of barley (g m^{-2})

Harvest	Days after sowing	Nitrogen rates (kg ha^{-1}) 0	50	100	Means SED ± 23.95
		BED ± 41.50			
H1	88	34.2	98.7	117.2	83.4
H2	106	84.0	282.9	313.3	226.7
H3	129	134.6	527.7	637.7	433.3
H4	143	249.6	775.4	1095.1	706.7
H5	154	275.7	784.1	1123.4	727.7
H6	178	269.6	780.3	1085.2	711.7
Means SED±16.94 ($p<0.05$).		174.62	541.5	728.7	

Materials and Methods

The experiment was carried out at the University College Farm, Aber, Gwynedd United Kingdom. The barley variety Atem was sown in first week of December and terminated on last day of May. The experiment was carried out in a glasshouse with no temperature control and without supplementary heating.

The experiment was sown, in 23 cm X 23 cm plastic pots, painted black on the outer sides. The pots were kept on benches along the sides and in the centre of each bench. Each pot had a hole drilled at the bottom for drainage. Nitrogen was broadcasted at the rate of 0, 50 and 100 kg ha^{-1} to the appropriate pots in first week of January. Barley was planted at a seed rate equivalent to 180 kg ha^{-1}. Having determined average seed weight, 24 seeds were required in each pot, arranged in four rows of six plants. The distance between rows and between plants within rows was 3.8 cm. Seeds of barley were sown at a depth of 4 cm. Two seeds were sown at each position within the pot and thinned, where necessary, to one plant per site after germination. The pots were watered once or twice a week. Before sowing soil was analyzed. It had a pH of 6.2, P content 21 ppm, K content 112 ppm, N content 0.11 percent and an organic matter content of 5.1 percent.

The experiment was arranged as a randomized complete block design with three replicates. Each block was on separate bench and contained 18 pots which were randomly assigned the nitrogen level and harvest time within each block.

80 kg phosphorus and 80 kg ha^{-1} potassium were applied to the experiment before sowing. One pot per replication was harvested at each harvest. The samples were transferred to the laboratory for weighing, drying, and analysis.

Plant samples were analyzed for total nitrogen using the kjeldahl method (AOAC, 1984) with a Kjeltec Auto 103 Analyser. The samples were digested using a blot digester-Tecam DG-1. Nitrogen content was then multipled by 6.25 to calculate crude protein percentage. MADF percent was determined using a fibretec system M-Tecam consisting of a hot extractor (1020) and cold (1020) extractor (AOAC, 1984).

The data collected from experiment were subjected to statistical analysis, using analysis of variance. Where treatments effects were found to be significant ($p<0.05$) treatment means were compared by using LSD test at 5 percent probability level (Steel and Torrie, 1984).

Table 4: Effect of harvest dates and nitrogen application on dry matter percentage of barley

Harvest	Days after sowing	Nitrogen rates (kg ha^{-1}) 0	50	100	Means SED ± 1.27
		SED ± 2.20			
H1	88	15.2	10.4	10.1	11.9
H2	106	17.3	15.9	13.7	15.6
H3	129	23.7	27.5	25.9	25.7
H4	143	29.3	33.3	32.6	31.7
H5	154	36.3	38.6	38.2	37.7
H6	178	50.6	59.0	58.1	55.9
Means		29.8	30.8	29.8 N.S	

Table 5: Effect of harvest dates and nitrogen application on green leaf area per plant of barley (cm^2)

Harvest	Days after Sowing	Nitrogen rates (kg ha^{-1}) 0	50	100	Means SED ± 6.7
H1	88	16.8	55.4	65.6	46.0
H2	106	27.7	74.7	102.2	68.2
H3	129	24.4	43.7	89.7	52.6
H4	143	18.6	28.3	38.3	28.3
H5	154	5.8	9.6	12.0	9.1
Means SED ± 5.19		18.7	42.3	61.6	

Table 6. Effect of harvest dates and nitrogen application on crude protein percentage of barley (CP percent)

Harvest	Days after sowing	Nitrogen rates (kg ha^{-1}) 0	50	100	Mean SED ± 0.99
H1	88	16.6	21.6	28.4	22.2
H2	106	7.9	7.7	10.7	8.8
H3	129	5.1	4.3	5.7	5.0
H4	143	4.5	4.1	4.9	4.5
H5	154	5.4	4.6	4.4	4.8
H6	178	5.6	3.9	4.3	4.6
Means SED ± 0.70					

Climatic conditions: Mean maximum and minimum temperature and sunshine hours during the growth period are given in Table 1. Maximum and minimum air temperature was recorded in the glasshouse and bright sunshine hours were recorded at a weather station located at a site about 1 km from the glasshouse. Monthly sunshine hours ranged from 0.9 to 8.0, while mean daily temperature each month ranged between 6.2 to 12.9°C during the period of the experiment.

Results

Fresh yield (FY): FY increased up to fourth harvest and subsequently declined at the fifth and sixth harvests (Table 2). The highest and lowest FY were obtained at the fourth and first harvest respectively. FY increased significantly ($p<0.05$) between each level of nitrogen application. On average the application of 100 kg N ha^{-1} increased FY 1785.1 g m^{-2} compared to 0 kg N ha^{-1}. The interaction between harvest and nitrogen rate was significant ($p<0.05$) and arose due to the non-significant differences between 50 and 100 kg nitrogen at the first harvest, whereas at the other harvests differences between 50 and 100 kg N ha^{-1} were significant ($p<0.05$).

Dry matter yield (DMY): Harvest date significantly ($p<0.05$) affected the DMY, which increased up to fifth harvest and then decreased slightly by the sixth harvest. The increase between the fourth and fifth harvests was not significant (Table 3). The DMY varied from 83.4 g at the first harvest to 727.7 g at the fifth harvest. 50 and 100 kg N ha^{-1} differed significantly ($p<0.05$) and both gave higher DMY than 0 kg N ha^{-1}. Nitrogen *harvest date was significant ($p<0.05$) and arose due to non-significant differences between 0 and 50 kg N ha^{-1} at the first harvest. Whereas at the other harvests the differences between 0 and 50 kg N ha^{-1} were significant ($p<0.05$).

Dry matter percentage (DM%): DM percent was significantly ($p<0.05$) affected by harvest date (Table 4). A significant increase in DM percent was observed at each successive harvest. DM percent increased from 11.9 at the first harvest to 55.9 at the sixth harvest. The nitrogen application did not affect the DM percent. The interaction between harvest and nitrogen rate was significant. The differences between nitrogen levels from the second to the fifth harvest were not significant ($p<0.05$) whereas at the first and sixth harvest both 50 and 100 kg N ha^{-1} produced significantly lower and higher DM percent respectively than 0 kg N ha^{-1}.

Green leaf area per plant (cm^2): The second harvest gave significantly ($p<0.05$) higher (68.2) green leaf area per plant compared to the other harvests. A decline in leaf area occurred from the second harvest (Table 5). A minimum green leaf area of 9.1 cm^2 was recorded at the fifth

Table 7: Effect of harvest dates and nitrogen application on modified acid detergent fibre percentage of barley

Harvest	Days after sowing	Nitrogen rates (kg ha^{-1}) 0	50	100	Means SED ± 0.99
H1	88	24.37	22.17	21.27	22.61
H2	106	27.29	23.36	23.96	24.87
H3	129	27.98	26.32	26.07	26.88
H4	143	28.65	27.75	26.98	27.79
H5	154	25.48	26.05	26.41	25.98
H6	178	23.62	26.49	26.05	25.39
Mean		26.23	25.36	25.12	
SED ± 0.43					

Table 8: Effect of harvest dates and nitrogen application on the plant height and crude protein yield

Harvest	Days after sowing	Plant height (Cm)	Crude protein Yield (g m^{-2})
H1	88	10.8	19.7
H2	106	47.8	20.7
H3	129	57.8	21.8
H4	143	67.5	31.8
H5	154	67.5	32.9
H6	178	67.6	30.8
SED ±		1.17	1.69
Nitrogen rate (kg ha^{-1})			
0		47.5	10.0
50		62.4	26.9
100		64.7	41.9
SED ±		0.83	1.19

*These are overall means across the treatments since interactions were not significant ($p<0.05$)

harvest. 50 and 700 kg N ha^{-1} produced significantly higher leaf area than 0 kg N ha^{-1}. The maximum (61.6) and minimum (18.7) leaf area was obtained at 0 and 100 kg N ha^{-1} respectively. The interaction between harvest and nitrogen rate was also significant due to the non-significant differences among nitrogen levels at the fourth and fifth harvests. At the sixth harvest green leaf area was not recorded due to senescence of all leaves.

Crude protein percentage (CP percent): Table 6 shows that the first harvest gave significantly ($p<0.05$) higher CP percent compared to the other harvest dates. A Significant decrease in CP percent was observed up to the third harvest. The highest (22.2) and lowest (4.6) CP percent was observed at the first and fourth harvest respectively. An increase of 0.3 percent was observed by the fifth harvest. 0 kg N ha^{-1} produced significantly ($p<0.05$) lower CP percent than 50 and 100 kg N ha^{-1}. CP percent increased significantly at each level of nitrogen application from 7.5 to 9.7 at 0 and 100 kg N ha^{-1} respectively. The interaction between treatments and harvest date was also significant ($p<0.05$). At the first harvest 50 and 100 kg N ha^{-1} nitrogen gave significantly ($p<0.05$) higher CP percent than 0 kg N ha^{-1} whereas from the second to the sixth harvest the differences between nitrogen levels were not significant ($p<0.05$).

Modified acid detergent fibre percentage (MADF percent): MADF percent was significantly ($p<0.05$) affected by harvest dates. MADF percent increased up to the fourth harvest but declined significantly by the fifth harvest (Table 7). The differences between the third and fourth harvests were not significant ($p<0.05$). The first and fourth harvests gave the lowest (22.61) and the highest (27.79) MADF percent respectively. MADE percent was significantly ($p<0.05$) affected by nitrogen application. MADE percent declined from 26.23 to 25.12 percent at 0 and 100 kg N ha^{-1} respectively, although there was no significant differences between MADE percent at 50 and 100 kg N ha^{-1}. The interaction between nitrogen and harvest date was significant ($p<0.05$) and arose mainly because at the first, second and sixth harvests 50 and 100 kg N h^{-1} gave significantly lower and higher MADF percent than 0 kg N ha^{-1} respectively.

Plant height (cm): The data presented in Table 8 indicates that a significant increase in plant height occurred up to the fourth harvest. Whereas, the differences between the fourth, fifth and sixth harvests were not significant ($p<0.05$). The maximum (67.6) and minimum (40.8) plant height was obtained at the first and sixth harvests respectively. Plant height increased from 47.5 cm to 64.7 cm at 0 and 100 kg N ha^{-1} respectively.

Crude protein yield (CPY): CPY increased significantly ($p<0.05$) by extending the harvest period (Table 8). The differences between the fourth, fifth and sixth harvest were not significant but these three harvest dates gave significantly ($p<0.05$) higher CPY than the preceding harvests. The crude protein yield increased from 10.0 to 41.9 g m^{-2} at 0 and 100 kg N ha^{-1} respectively. The interaction between treatment and harvest date was not significant ($p<0.05$).

Discussion

Green leaf area per plant increased between the first and second harvest for each nitrogen treatment and then declined due to senescence. Nitrogen application also increased green leaf area significantly ($p<0.05$). Leaf area increased from 18.7 cm^2 at 0 kg N ha^{-1} to 61.6 cm^2 at 100 kg N ha^{-1}. Similar results have been reported by Nannetti *et al*. (1990) and Ali (1988).

Plant height increased between each level of nitrogen application. Increase in plant height with nitrogen has b reported by Nannetti *et al*. (1990).

CP percent in whole barley plants decreased with time and remained constant near maturity. It ranged from 212 at the first harvest to 4.5 at the fourth harvest after which it increased to 4.8 at the fifth harvest. Similar findings have been reported by Rodriguez *et al*. (1990) and Papakosta and Gagianas (1991). They attributed the decreasing protein concentration to a dilution effect as a result of plant growth. Through increasing nitrogen application, CP percent was increased which is in agreement with published work of DiRienzo *et al*. (1991). The interaction between treatment and harvest times was also significant ($p<0.05$) due mainly to the significant increase in CP percent observed following nitrogen application at the first harvest only.

MADF percent increased with harvest time and reached a maximum at the fourth harvest and then decreased significantly ($p<0.05$) by the fifth harvest. The formation of grains might have caused a decrease in MADF percent. The application of nitrogen decreased MADF percent from 26.2 percent at 0 kg N ha^{-1} to 25.1 percent at 100 kg N ha^{-1} and these results confirm the findings of Zioek and Szmigiel (1982) for maize. However they are in contrast to those of DiRienzo *et al*. (1991) for barley.

DM percent increased as the period before harvest was extended and significant increases were observed between each harvest. A large increase in DM percent was observed between the fourth and fifth harvests. An increase in DM percent with crop maturity has been reported previously by Droushiotis (1984), Although the nitrogen application did not affect the mean DM percent significantly ($p<0.05$), the application of 50 and 100 kg N ha^{-1} produced about 2 and 1 percent higher DM than the 0 kg N ha^{-1} respectively. DiRienzo *et al*. (1987) reported that nitrogen application increased DM percent of barley. In contrast DiRienzo *et al*. (1991) reported lower DM percent with nitrogen which was attributed to a delay in maturity following application.

Generally DMY increased up to the fifth harvest and subsequently decreased by the sixth harvest. Similar trends have been reported by Droushiotis (1984). There was a significant increase in DMY at each level of nitrogen application, a result that agrees with published work of DiRienzo *et al*. (1987). CPY also increased with harvest date and ranged from 19.7 g m^{-2} at the first harvest to 32.9 g m^{-2} at the fifth harvest. CPY also increased with increasing nitrogen application from 10.0 g m^{-2} to 41.9 g m^{-2} as reported by DiRienzo *et al*. (1986).

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