

# Pattern of Nitrogen Distribution in Barley Grains Grown in the Field

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## ABSTRACT

J. Inst. Brew. 109(2), 110–113, 2003

Single grain analysis showed that barley grains synthesized different levels of total nitrogen during development in a commercial field of barley. The difference in total nitrogen content of the individual barley grains was influenced by the topography of the field in which the barley was grown. Barley samples obtained from the higher ground and the peripheries of the field had incorporated lower levels of total nitrogen in the grain. In contrast, barley grains harvested from valley areas in the middle of the field incorporated a higher level of total nitrogen.

**Key words:** Barley, field, nitrogen, topography.

## INTRODUCTION

Production of high quality malt depends on a number of factors. One of the most important parameters is the nitrogen content of the grains of malting barley<sup>1,2</sup>. Grain size distribution is another important factor because grains of different sizes will absorb differing amounts of water during steeping and hence modify at different rates during malting. Small grains (<2.2 mm) tend to have higher out-of-steep moistures than larger grains. This difference in grain size also affects nitrogen content of grain samples – small grains have higher percentages of nitrogen than larger grains<sup>3</sup>.

Uniform distribution of acceptable grain size is preferred by the industry, but can be difficult to achieve because of the nature of the topography of the field from which barley is grown and harvested. Although variations in nitrogen are likely to occur, there is very little evidence that this is the case. In this study, barley samples were obtained from the same field, but from different parts of the field. Single grain analysis for nitrogen content of grains was carried out. The aim was to assess the variations in nitrogen of the individual grains that constitute a barley sample.

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## MATERIALS AND METHODS

### Sample collection

Samples used in this study were obtained from barleys growing in the field, prior to harvest, but at different parts of the field. Samples were designated as “top”, representing samples obtained from hills in the field; “middle”, representing samples from the low-lying valley of the field; and “bottom”, representing samples from the periphery area at the middle of the field. The total barley mix (TMB) was obtained after the field was harvested.

### Grain analysis for nitrogen

Samples representing the three areas were collected by hand. Exactly 100 grains collected from each part of the field, as well as 100 grains of a mixture of the grains from the three parts of the field were analysed. Single grain analyses of the samples from each part of the field, as well as the mixture were carried out using the Leco FP428 thermal conductivity (Dumas) based instrument with attached Dot matrix printer/plotter and high-resolution electric luminescent display.

## RESULTS AND DISCUSSION

Fig. 1 shows the results of the pattern of nitrogen distribution in individual grains obtained from different parts of a large barley field. The results in Fig. 1 and Table I show that each grain incorporated different levels of nitrogen during grain development. It is also evident from the results in Fig. 1 and Table I that the barley grains

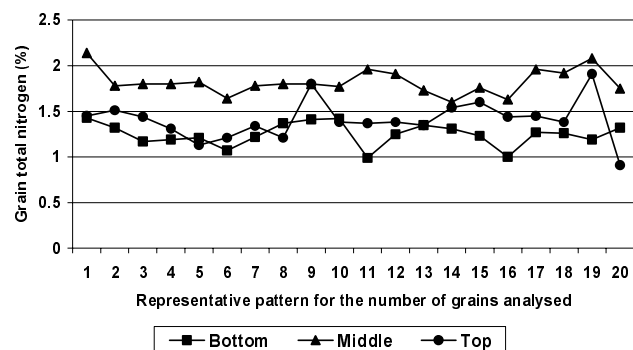


Fig. 1. Total nitrogen of single grains from different areas of a barley field. Top, middle and bottoms represent barley samples obtained from the “hills”, “low-lying valley” and “periphery” of the field (see Materials and Methods section).

obtained from the valley (“middle”) of the field incorporated higher levels of nitrogen than grains taken from either the hill (“top”) or the periphery (“bottom”) of the field. It would seem that the topography of the field influenced the nitrogen of the grains harvested from that field. Although moisture may have influenced these results we did not assess moisture level of the field or humidity during grain development.

Notwithstanding, the results shown in Fig. 1 and Table I suggest that soil conditions in the valley areas promoted high protein production in the grain. In contrast, higher hilly areas encouraged lower protein production in the grain. However, it is possible that higher levels of soil

nitrogen in the valley areas, than in the hilly areas of the field, are likely to have caused the differences observed in the grains analysed.

In order to investigate the relationship between grain weight and grain nitrogen content, grains were automatically weighed and their weights were recorded prior to nitrogen determination (see methods section). It is clear from the results shown in Figs. 2, 3 and 4 that no relationship was found between grain total nitrogen and grain weight. However, it is important to mention that grain size was not determined. Therefore, there could be a different relationship between grain weight and nitrogen and grain size (i.e., large and small grains) and nitrogen<sup>3</sup>.

Table I. Total nitrogen content (% w/w) of individual barley grains.

S/N	TMB	Top	Middle	Bottom	S/N	TMB	Top	Middle	Bottom
1	1.37	1.45	2.14	1.43	51	1.43	1.29	1.77	1.22
2	1.23	1.51	1.78	1.32	52	1.26	1.45	1.70	1.25
3	1.43	1.44	1.80	1.17	53	1.16	1.35	1.79	1.41
4	1.47	1.31	1.80	1.19	54	1.38	1.38	1.77	1.18
5	1.48	1.13	1.82	1.21	55	1.29	1.51	1.61	1.32
6	1.44	1.21	1.64	1.07	56	1.32	1.40	1.90	1.38
7	1.14	1.34	1.78	1.22	57	1.59	1.23	1.24	1.64
8	1.20	1.21	1.80	1.37	58	1.54	1.34	1.69	1.42
9	1.38	1.80	1.80	1.41	59	1.53	1.38	2.07	1.32
10	1.20	1.38	1.77	1.42	60	1.23	1.43	1.69	1.26
11	1.48	1.37	1.96	0.99	61	1.38	1.66	1.83	1.09
12	1.07	1.38	1.91	1.25	62	1.66	1.35	1.45	1.19
13	1.76	1.35	1.73	1.35	63	1.54	1.22	2.00	1.18
14	1.64	1.54	1.60	1.31	64	1.36	1.36	1.97	1.33
15	1.13	1.60	1.76	1.23	65	1.29	1.38	1.75	1.37
16	1.27	1.44	1.63	1.00	66	1.40	1.71	1.74	1.08
17	1.32	1.45	1.96	1.27	67	1.58	1.31	1.86	1.29
18	1.08	1.38	1.92	1.26	68	1.59	2.01	1.95	1.30
19	1.24	1.91	2.08	1.19	69	1.24	1.38	1.66	1.25
20	1.57	0.91	1.75	1.32	70	1.74	1.41	1.88	1.12
21	1.33	1.66	1.82	1.29	71	1.28	1.16	1.84	1.39
22	1.07	1.30	1.76	1.20	72	1.48	1.11	2.15	1.31
23	1.05	1.13	1.46	1.26	73	1.40	1.41	2.11	1.29
24	1.19	1.85	1.46	1.26	74	1.52	1.09	1.18	1.73
25	1.09	1.29	1.64	1.07	75	1.10	1.38	1.69	1.14
26	1.24	1.32	1.58	1.25	76	1.48	1.35	1.59	1.19
27	1.52	1.13	1.69	1.02	77	1.50	1.48	1.55	1.24
28	1.35	1.46	1.53	1.30	78	1.16	1.69	1.76	1.33
29	1.44	1.18	1.65	1.15	79	1.31	1.11	1.57	1.17
30	1.36	1.18	1.83	1.20	80	1.32	1.45	1.51	1.28
31	1.34	1.04	1.42	1.31	81	1.90	1.35	1.56	1.27
32	1.13	1.32	1.69	1.23	82	1.57	1.28	1.82	1.31
33	1.49	1.19	1.95	1.24	83	1.89	1.18	1.29	1.23
34	2.06	1.05	1.93	1.26	84	1.45	1.27	1.79	1.19
35	1.10	1.17	2.07	1.14	85	1.15	1.30	1.62	1.53
36	1.27	1.35	1.47	1.30	86	1.69	1.58	1.76	1.04
37	1.16	1.30	1.81	1.28	87	1.39	1.86	1.39	1.40
38	1.38	1.12	1.68	1.72	88	1.41	1.61	1.67	1.26
39	1.27	1.51	1.83	1.05	89	1.22	1.49	1.89	1.14
40	1.07	1.68	1.54	1.42	90	1.35	1.15	1.41	1.06
41	1.12	1.41	1.87	1.25	91	1.47	1.42	2.18	1.23
42	1.66	1.32	1.72	1.34	92	1.46	1.92	1.68	1.23
43	1.81	1.46	1.44	1.26	93	1.27	1.36	1.75	1.15
44	1.34	1.73	1.60	1.30	94	1.26	1.29	2.04	1.20
45	1.49	1.49	1.66	1.19	95	1.43	1.32	1.73	1.32
46	1.62	2.11	1.67	1.01	96	1.67	1.13	1.80	1.20
47	1.18	1.42	1.45	1.44	97	1.51	1.38	1.74	1.13
48	1.49	1.20	1.47	1.13	98	1.73	1.79	1.75	1.46
49	1.41	1.48	1.47	1.20	99	1.54	1.11	1.77	1.04
50	1.74	1.23	1.60	1.13	100	1.55	1.26	1.80	1.09
					Average (as is)	1.40	1.39	1.73	1.25
					Milled sample	1.48	1.45	1.84	1.45

TMB = Total Barley Mix (control). “Top”, “middle” and “bottoms” represent barley samples obtained from the “hills”, “low-lying valley” and periphery area of the field respectively.

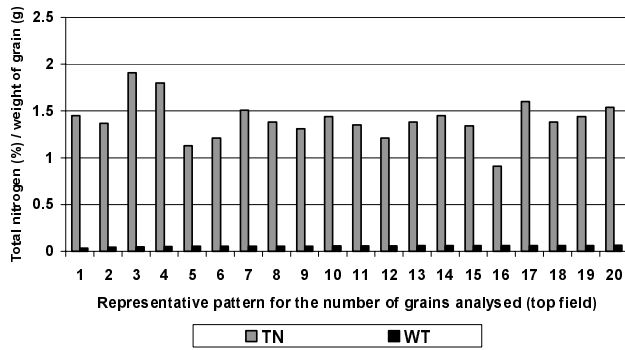


Fig. 2. Relationship between single grain weight and total nitrogen content. “Top” represents barley samples obtained from the “hills” of the field (see Materials and Methods section).

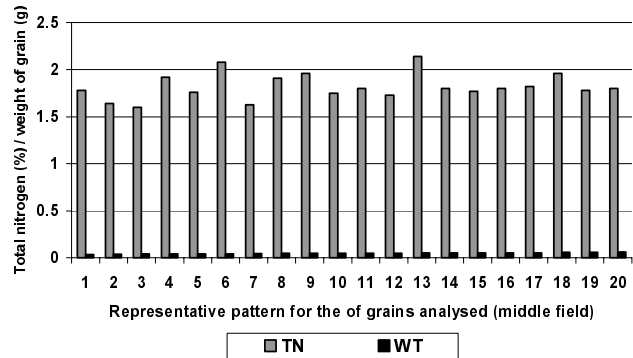


Fig. 3. Relationship between single grain weight and total nitrogen content. “Middle” represents barley samples obtained from the “low-lying valley” of the field (see Materials and Methods section).

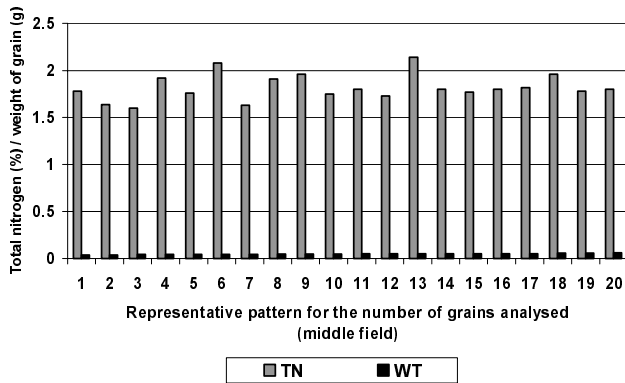


Fig. 4. Relationship between single grain weight and total nitrogen content. “Bottoms” represents barley samples obtained from the periphery area of the field (see Materials and Methods section).

In Fig. 5, the range of values of nitrogen distribution in the barley samples studied, are presented. It can be seen from the results in Fig. 5 that the sample of barley comprising the mix (TMB) had a large proportion of grains with total nitrogen in the range of 1.30–1.49%. Grains

with total nitrogen in the range of 2.10–2.29% were absent. It is worth noting that grains obtained from the hilly end of the field had a large proportions of grains with total nitrogen in the range of 1.30–1.49%, whilst the number of grains with total nitrogen in the range of 2.10–2.29% was minimal. In contrast, barley samples obtained from the valley (middle) part of the field had higher proportions of grains with total nitrogen in the range of 1.50–1.69% and 1.70–1.89%. However, these samples had a significant number of grains with total nitrogen in the ranges of 1.90–2.09% and 2.10–2.29%.

It is important to note in Fig. 5 that grains from the hill top of the field and grains from the bottom periphery of the field contained grains with the lowest range of total nitrogen (0.70–1.09%). Such low nitrogen grains were absent from the barley samples obtained from the valley of the field. The total nitrogen content of the sample gives no indication of nitrogen distribution within the sample. In this study it is evident that the topography of the field could influence the nitrogen distribution in malting barley and, because large differences in protein may influence malting performance<sup>4</sup>, impact on malt homogeneity.

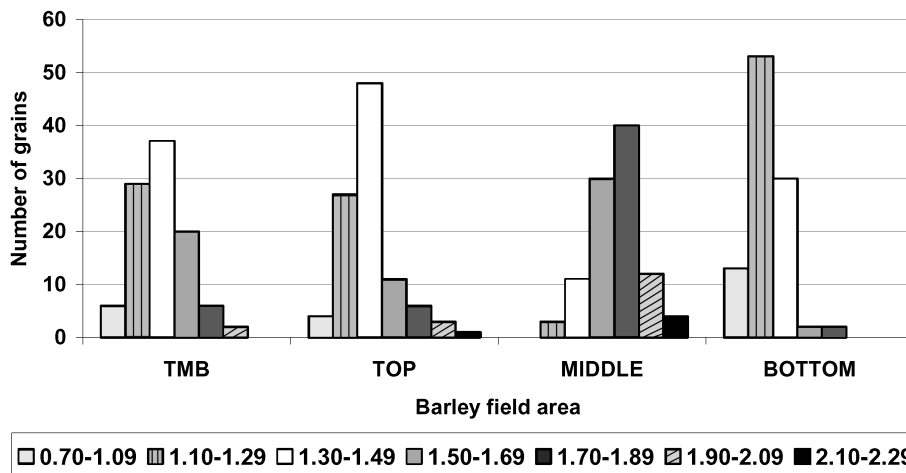


Fig. 5. Total nitrogen distribution in 100 single grains of different barley samples. TMB = Total Barley Mix (control). “Top”, “middle” and “bottoms” represent barley samples obtained from the “hills”, “low-lying valley” and periphery area of the field respectively (see Materials and Methods section).

## CONCLUSION

Although a range of well known factors, such as soil type, drainage, exposure to wind and disease may influence the grain characteristic, the work reported in this paper showed that the topography of the field in which barley was grown is an important factor which could influence malting quality. There is considerable commercial significance in these results in that growers of malting barley must ensure representative samples from each field are collected for submission to the purchaser of the crop. A hastily taken sample from the first combine harvester cuttings could lead to rejection of a potentially acceptable crop or vice versa.

## ACKNOWLEDGEMENT

The authors are grateful to J. P. Simpson & Co Limited for the use of their laboratory for this study, and the laboratory staff – Dr. D. J. Griffiths, Alistair Mitchell, Raymond Chisholm and

Katherine Taylor for their technical assistance. The first author acknowledges the continued support of Enugu State University of Science and Technology, Enugu, Nigeria.

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(Manuscript accepted for publication April 2003)