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Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

Harvest index for biomass and nitrogen in maize crops limited by nitrogen and water

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Introduction

Environment and crop management cause significant variation in the N economy of maize crops. Nitrogen harvest index (NHI), the ratio between N uptake in grain and N uptake in grain plus straw[2], is an important guide to understanding N and water limitations to crops. High NHI is strongly correlated with high grain N concentration (Ng%)[2] and high Ng% is usually indicative of high grain quality (protein = Ng% x 5.6)[3]. We examined NHI and the Ng% of maize grown under constrained N and soil water conditions in New Zealand.

Materials and Methods

Two experiments (A & B)[4,5] were carried out in consecutive seasons (A: 2011–2012 and B: 2012–2013), at Lincoln, Canterbury, New Zealand, on a deep (>1.6 m) Templeton silt loam soil[6]. Treatments were five N application rates (0–400 kg/ha) in Exp. A, and three N application rates (0–250) in Exp. B (within fully irrigated or dryland conditions).

Volumetric soil moisture content was determined by Time Domain Reflectometry in the top 0.20 m soil depth, and with a neutron probe in 0.20 m increments from 0.20 to 1.60 m soil depth.

Final biomass and grain yield (GY) were determined on 30 April 2012 in Exp. A, and on 10 April 2013 in Exp. B. A 2- to 3-plant subsample was dried at 60°C for % dry matter (DM). Subsamples were ground to pass through a 1 mm screen and N concentration was determined with a LECO TruSpec C/N analyser. Yield components were determined for Experiment B only.

All statistical analysis (GenStat v.17; VSN International) included ANOVA tests for interactions and main effects, with means separation by Fisher's protected least significant difference (LSD) tests (α = 0.05).

Results and Discussion

Total DM yield and GY increased with increasing N supply (Fig. 1a). Nitrogen supply had no significant effect on either HI or NHI (Fig. 1a, c) within the same water treatments. The HI of 0.47–0.53 was similar to the range of 0.43–0.50 reported for irrigated maize[7-9].

Both HI and NHI varied with water treatments in Exp. B (Fig. 1). The HI was lower at 0.47 for the dryland crops than the 0.53 for the irrigated crops. This could be attributed to the high number of ears/plant, grains/ear and grains/m² for the irrigated compared with the dryland crops (Table 1). Furthermore the 1000-grain weight was also higher for the irrigated than dryland crops, similar to reports in literature[8].

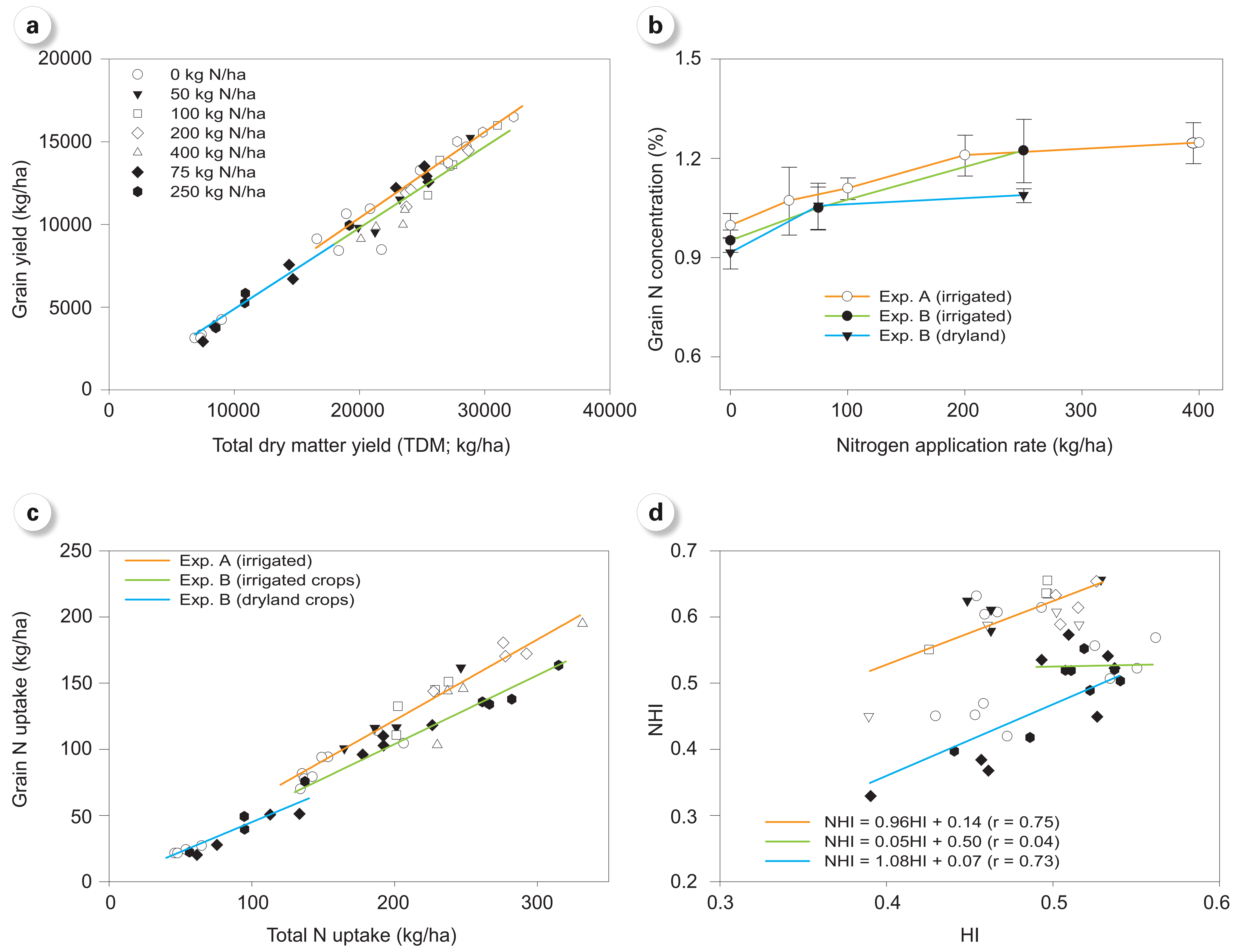

Fig. 1: The relationship between grain and total yield (HI) (a), (b) grain nitrogen (N) concentration and N application rate, (c) grain and total N uptake (NHI) and (d) the relationship between NHI and HI for maize crops grown under different irrigation (orange & green lines; irrigated and blue lines; dryland) and N rates of application at Lincoln, New Zealand in two consecutive seasons. Vertical bars are standard errors of differences of the means.

The Ng% increased (Fig. 1b) from 0.97% to 1.1% with water supply, and from 0.92% for the 0 kg N/ha crops to 1.25% for the 200–250 kg N/ha crops in both experiments, which is within range of 0.98–1.1% reported in the literature[9]. Overall, NHI differences with water supply (Fig. 1c) are supported by the differences in Ng% across the N rates (Fig. 1b). The increase of Ng% with both water and N supply (Fig. 1b) meant that the associated protein content of the maize grain also increased, based on the established relationship between Ng% and protein content[8]. The Ng% reached a maximum with application of about 250 kg N/ha in both experiments. Fertiliser N applied in excess of this rate would be of no economic value.

Table 1: Yield components for maize crops grown under differing water and nitrogen rate at Lincoln, New Zealand in the 2012–13 season.

Treatments	Ears/plant	Kernels/row	Kernel/m²	1000-kernel weight (g)
Grand mean	1.6	24	967	221
Water regime				
a) Fully irrigated	2.0	30	1294	250
b) Dryland	1.2	17	641	191
Nitrogen rate (kg N/ha)				
0	1.5	22	866	196
75	1.6	25	960	238
250	1.6	25	1076	228
F-tests				
Water (W)	***	***	***	***
N rate (N)	*	*	ns	***
W*N	ns	ns	ns	ns

Conclusions

- Ng% increased with both water and N supply.
- The NHI was closely related to the amount of GY. Therefore, improving the HI of maize crops is one way to improve the ability of the crops to utilise N from both soil and fertiliser sources.
- Treatments with high water availability caused higher NHI values in crops.

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