Effect of nitrogen fertilizer rate on wheat flour extensibility

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1. Background & Objectives

Nitrogen (N) fertilization in wheat is essential to obtain the desired grain yield and quality. One of the characteristics of wheat flour that determine its performance during baking is the extensibility. Increases in N fertilizer rate promote increments of dough extensibility (Garrido-Lestache et al., 2004). The objective of this work was to know how this increment is affected by year and genotype.

2. Materials & Methods

Field trials were conducted during five years at three sites in Navarra (northern Spain) under a humid Mediterranean climate with a randomized complete block design with four replications. Five to six N fertilization treatments (urea, 46%) were used, including a control without N fertilization. Plots were rain-fed, except in 2009/10, when they received irrigation. One to four bread wheat cultivars (*Triticum aestivum* L.) were sown. Yield response to N rate (Y) (t ha^{-1} on a 120 g kg^{-1} water basis) was fitted to a quadratic-plus-plateau model, defined by equation 1 and 2.

$$Y = a + bN + cN2 \text{ if } N < \text{Nop} \quad [1]$$
$$Y = M \text{ if } N \geq \text{Nop} \quad [2]$$

Where N is the fertilizer rate (kg N ha^{-1}), a is grain yield predicted for the unfertilized control treatment, b and c are linear and quadratic coefficients, respectively, and Nop is the intersection of the two functions (the smallest N rate required to reach M, the plateau yield). Grain samples were milled to white flour. Dough extensibility (L) (mm) was assessed by Chopin Alveograph. Extensibility response to N (L) was fitted to a linear model, defined by equation 3.

$$L = d + eN \quad [3]$$

Where N is the fertilizer rate (kg N ha^{-1}), d is the extensibility predicted for the unfertilized control treatment and e is the linear coefficient. Extensibility for Nop treatment (L_{Nop}) was calculated for each year introducing Nop values in equation 3.

3. Results & Discussion

Yield response to N followed a quadratic-plus-plateau model. In contrast, extensibility response to N followed a linear model, indicating that flour quality can be improved by application of N rates higher than Nop. Maximum yield, Nop and L_{Nop} varied among cultivars and years, showing the effects of genotype, site, particularly soil N mineral content before fertilization, weather and management practices like irrigation (Table 1). Despite L models were different for each cultivar and year, linear coefficients were very similar, indicating that in most cases L increase per N fertilizer unit had a value close to 0.3 mm. A different trend observed for Berdún in 2006/07 might be explained by a lower efficiency of N fertilizer. Calculated values that relate N rate and L to Nop and L_{Nop} allowed to establish a single correlation that included all cultivars and years (Figure 1). Extensibility response to N fertilizer was the same within the fertilizer rate range in which N was

still limiting grain yield (N rate < Nop) and under non-limiting conditions (N rate > Nop), when N absorbed can be used to increase grain N content and breadmaking quality (Johansson et al., 2001).

Table 1. Fitting models of yield (Y) (880 g kg^{-1} on dry matter basis) and dough extensibility (L) related to N rate (x).

Year	Cultivar	Yield model ($x < N_{op}$)	Yield model ($x \geq N_{op}$)	Nop	R^2	L model	L_{Nop}	R^2
		kg ha^{-1}	kg ha^{-1}	kg N ha^{-1}		mm	mm	
2005/06	Berdún	$Y = -0.11\ x^2 + 35.1\ x + 3651$	$Y = 6451$	159	0.80	$L = 0.4\ x + 72.5$	140	0.95
2006/07	Berdún	$Y = -0.02\ x^2 + 16.1\ x + 2275$	$Y = 4318$	151	0.92	$L = 0.1\ x + 111.1$	126	0.42
2007/08	Berdún	$Y = -0.02\ x^2 + 13.0\ x + 1711$	$Y = 3459$	190	0.84	$L = 0.3\ x + 78.2$	126	0.90
2008/09	Berdún	$Y = -0.11\ x^2 + 29.5\ x + 4419$	$Y = 6394$	139	0.90	$L = 0.3\ x + 134.1$	177	0.86
2009/10	Berdún	$Y = -0.09\ x^2 + 38.5\ x + 6045$	$Y = 9632$	130	0.91	$L = 0.3\ x + 73.5$	119	0.92
2009/10	Osado	$Y = -0.05\ x^2 + 39.3\ x + 5544$	$Y = 9706$	125	0.89	$L = 0.3\ x + 100.5$	145	0.96
2009/10	Badiel	$Y = -0.20\ x^2 + 63.4\ x + 5430$	$Y = 10143$	122	0.91	$L = 0.3\ x + 40.2$	90	0.99
2009/10	Nogal	$Y = -0.06\ x^2 + 46.1\ x + 6335$	$Y = 11226$	125	0.94	$L = 0.2\ x + 71.1$	101	0.98

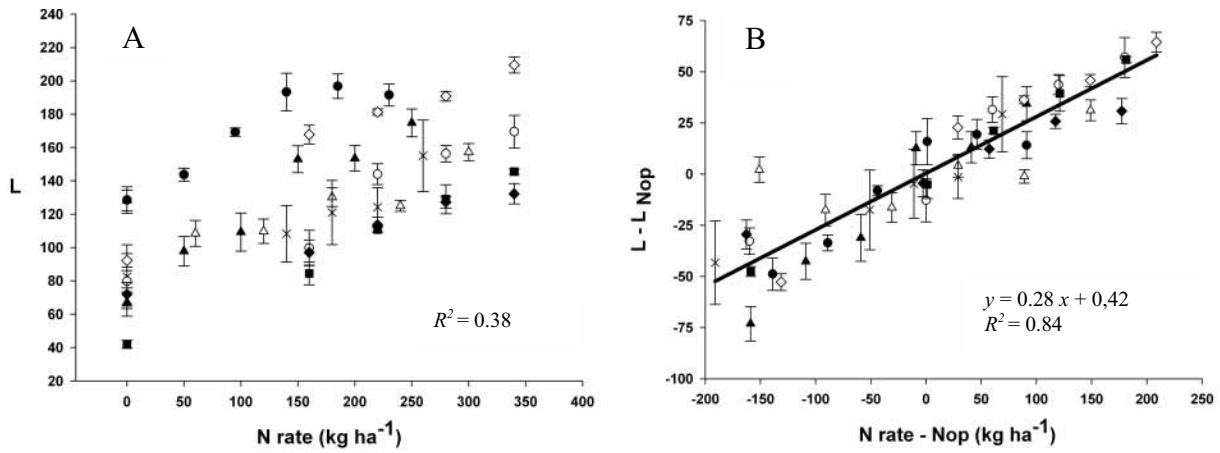

Figure 1. Correlation between N fertilizer rate (kg ha^{-1}) and dough extensibility (mm) (A) and between N rate minus N optimum for yield (Nop), and extensibility minus extensibility calculated for Nop (B) in Berdún 2005/06 (▲), 2006/07 (Δ), 2007/08 (x), 2008/09 (●), 2009/10 (○), Osado 2009/10 (◊), Badiel 2009/10 (■) and Nogal 2009/10 (♦).

4. Conclusion

Extensibility for each N rate varied among cultivars and years, due to genotype, environmental and soil conditions. Within each cultivar and year, extensibility increased linearly with N rate independent of whether N rate was under or above Nop. A single regression could be made for all years and cultivars, indicating an increase of extensibility of 0.3 mm per kg N, approximately.

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