

Supplementary Figure S1. Weather conditions for each site during the growing period. (A) Site 1, (B) Site 2 and (C) Site 3.





Supplementary Figure S2. Relationship between element concentrations of wheat flour (*Triticum aestivum* L.) values obtained with the HR ICP-MS and XRF methods. (A) K content, (B) P content, (C) Mg content, (D) S content, (E) Ca content, (F) Fe content, (G) Zn content and (H) Mn content.



Supplementary Figure S3. Relationship between element concentrations of wheat straw (*Triticum aestivum* L.) values obtained with the HR ICP-MS and XRF methods. (A) K content, (B) P content, (C) Mg content, (D) S content, (E) Ca content, (F) Fe content, (G) Mn content and (H) Ni content.



Supplementary Figure S4. Schematic representation of the ANOVA for yield, spike number per square metre, grain number per spike, grain number per square metre, thousand grain weight (TGW) and specific weight. (A) Global ANOVA using data obtained in the three sites and with the two fertilizers, (B) ANOVA Urea using data obtained from the three sites with urea fertilizer and (C) ANOVA UAN using data obtained from the three sites with UAN fertilizer.



Supplementary Figure S5. Schematic representation of the ANOVA of the %N in flag leaf at heading, %N in flag leaf during seed development, %N in grain, %N in straw, total grain N and N use efficiency (NUE). (A) Global ANOVA using data obtained in the three sites and with the two fertilizers, (B) ANOVA Urea using data obtained from the three sites with urea fertilizer and (C) ANOVA UAN using data obtained from the three sites with UAN fertilizer.



Supplementary Figure S6. Schematic representation of the ANOVA of the grain ionome (elements detected in all samples by XRF; Ca, Fe, K, Mg, Mn, P, S and Zn). (A) Global ANOVA using data obtained in the three sites and with the two fertilizers, (B) ANOVA Urea using data obtained from the three sites with urea fertilizer and (C) ANOVA UAN using data obtained from the three sites with UAN fertilizer.



Supplementary Figure S7. Schematic representation of the ANOVA of the straw ionome (elements detected in all samples by XRF; Ca, Fe, K, Mg and S). (A) Global ANOVA using data obtained from the three sites and with the two fertilizers, (B) ANOVA Urea using data obtained from the three sites with urea fertilizer and (C) ANOVA UAN using data obtained from the three sites with UAN fertilizer.

	Site 1	Site 2	Site 3
Location	49.26491, -0.87763	49.512660, 0.409829	48.851115, 0.023732
Previous crop	Beta vulgaris	Linum usitatissimum	Medicago sativa
Wheat cultivar	Sacramento	Libravo	Chevignon
Sowing date	17-11-2018	16/10/2018	16-10-2018
Organic matter input	Yes	No	No
Soil type	Clay loams / Frank loams	Deep silt	Superficial clay limestone
pH (water)	6.2	7.3	8.4
CEC (mol kg ⁻¹)	9.5	8.5	10.8
Organic matter (%)	2.4	2.1	3.4
C/N Ratio	Not determined	8.1	7.6
Total N (%)	Not determined	0.15	0.26
Organic C (%)	1.42	1.22	1.98
Available P (ppm)	132	101	62
Exchangeable K (ppm)	168	238	254
Exchangeable Mg (ppm)	104	99	216
CaO (‰)	2.1	3.6	12.3

Supplementary Table S1. Location, wheat cultivars and soil properties of the three field trials

	Site 1	Site 2	Site 3
Humus effect	65	50	30
Previous crop effect	20	0	40
M.O. supply effect	12	0	0
N uptake	10	29	26
N residue (NO3 ⁻ /NH4 ⁺)	33 (25/8)	35 (33/2)	42 (34/8)
Total N soil supply (kgN ha-1)	140	114	138
Crop needs	272	304	270
N remaining	20	20	20
Total N needs	292	324	290
N fertilizer	152	210	152
Supply 1 (Tillering, BBCH 21)	61	100	62
Supply 2 (Stem elongation, BBCH 31)	31	50	30
Supply 3 (Flag leaf extended), BBCH 39)	60	60	60

Supplementary Table S2. Nitrogen management in the three field trials