

Table S1: Components of variance (Var.cp.) and respective *F* tests from the analysis of variance across nitrogen (N) -levels for N related traits. 108 hybrids (54 semi-dwarf and 54 normal type) were tested at low and at high N supply. Data are from three environments: Göttingen 2011-2012 and 2012-2013, and Einbeck 2012-2013. Negative estimates for variance components are given by “0”.

Source	Df ^a	N content straw (%) Var.cp	N in straw (kg N ha ⁻¹) Var.cp	N content seeds (%) Var.cp	N in seeds (kg N ha ⁻¹) Var.cp	Seed protein content (%) Var.cp	NHI Var.cp	Total N uptake (kg N ha ⁻¹) Var.cp	N uptake efficiency Var.cp	N utilization efficiency Var.cp	N use efficiency Var.cp
Environment (E)	2	0.0007 ⁺	30.7*	0.0042*	472.7**	0.16*	0.0018*	603.5**	0.0014	2.30	2.03
Nitrogen (N)	1	0.0514**	153.4**	0.1042*	822.9*	4.07*	0.0003	1702.7*	0.0291*	10.79 ⁺	51.20**
Growth type (T)	1	0.0012 ⁺	3.7**	0	0.2	0	0.0004	0	0	0.70*	1.60 ⁺
Genotype (G) : T	106	0.0002	4.1**	0.0012**	5.0**	0.05**	0.0003**	5.4*	0.0002 ⁺	0.42**	0.34**
N × E	2	0.0009	0.5**	0.0065**	122.7**	0.25**	0.0003**	128.8**	0.0001	1.94*	1.68**
T × E	2	0.0003**	0	0.0004*	15.4**	0.01*	0.0002**	17.15**	0.0013	0.12 ⁺	0.35**
T × N	1	0.0018**	0	0.0008	0	0.03	0.0001 ⁺	0	0.0026	0.48**	1.76**
G × E : T	212	0.0011**	4.9**	0.0007*	11.33**	0.03*	0.0002**	23.1**	0.0007**	0.17 ⁺	0.32**
G × N : T	106	0.0001	1.4 ⁺	0	0	0	0.0000	0	0	0.02	0.09

^a Df; degrees of freedom

+Significant at the 0.1 probability level

*Significant at the 0.05 probability level.

**Significant at the 0.01 probability level

Table S2: The *bzh*-locus and quantitative trait loci (QTL) for nitrogen (N) -related traits estimated for single environments. 100 hybrids derived from doubled-haploid population 'Alesi × H30' crosses with a male-sterile tester were grown at low and high N supply at locations Einbeck and Göttingen in the 2010-2011, 2011-2012, and 2012-2013 seasons.

QTL name ^a	Linkage group	Confidence interval	Position (cM)	maximum LOD ^b	Effect ^c	R ² ^d
<i>bzh</i>-locus	A06		3.0			
----- <i>low nitrogen supply</i> -----						
N content straw (%)^f						
<u>N%straw-N0-A06-Go2011</u>	A06	0.0 – 2.9	0.0	4.2	-0.02	0.12
<u>N%straw-N0-A09-Ei2012</u>	A09	4.5 – 14.9	11.9	3.2	-0.03	0.12
Seed protein content (%)^g						
<u>Pro%-N0-A06-Go2012</u>	A06	0.7 – 10.2	3.0	11.8	0.28	0.31
<u>Pro%-N0-A06-Go2013</u>	A06	2.6 – 18.0	10.0	9.3	0.32	0.37
<u>Pro%-N0-A08-Ei2011</u>	A08	0.0 – 17.8	16.8	2.8	-0.13	0.06
N harvest index^e						
<u>NHI-N0-A06-Go2011</u>	A06	0.0 – 2.1	0.0	21.2	-0.04	0.46
<u>NHI-N0-A06-Go2012</u>	A06	0.9 – 9.0	3.0	17.4	-0.03	0.47
Total N uptake (kg N ha⁻¹)^e						
<u>NkgMat-N0-C06-Go2012</u>	C06	0.8 – 11.6	3.0	7.4	-2.07	0.21
<u>NkgMat-N0-C06-Go2012</u>	C06	64.5 – 70.2	67.2	4.8	1.63	0.13
N uptake efficiency^e						
<u>NupEff-N0-A06-Go2011</u>	A06	0.0 – 2.0	1.0	11.5	-0.06	0.28
<u>NupEff-N0-A06-Go2011</u>	A06	0.8 – 11.8	3.0	7.5	-0.04	0.22
N utilization efficiency^e						
<u>NutEff-N0-A06-Go2012</u>	A06	0.9 – 8.5	3.0	19.1	-1.40	0.48
N use efficiency^e						
<u>NUE-N0-A06-Go2011</u>	A06	0.0 – 2.2	1.0	25.1	-2.46	0.51
<u>NUE-N0-C06-Go2011</u>	C06	65.9 – 79.3	67.5	3.0	0.67	0.04
<u>NUE-N0-C08-Go2012</u>	C08	13.3 – 22.5	19.3	3.5	1.54	0.13
<u>NUE-N0-C09-Go2011</u>	C09	20.3 – 55.7	48.7	3.1	-0.69	0.04
----- <i>high nitrogen supply</i> -----						
N content straw (%)^e						
<u>N%straw-N1-A06-Ei2012</u>	A06	1.3 – 12.2	3.0	11.4	-0.03	0.34
<u>N%straw-N1-A06-Go2012</u>	A06	4.1 – 26.2	17.0	7.0	-0.06	0.31
<u>N%straw-N1-C06-Ei2012</u>	C06	32.8 – 47.3	42.4	3.3	0.02	0.08
<u>N%straw-N1-C06-Go2012</u>	C06	48.5 – 69.3	60.3	2.7	0.03	0.07
Seed protein content (%)^e						
<u>Pro%-N1-A06-Ei2012</u>	A06	0.0 – 12.9	1.0	14.2	-0.36	0.39
<u>Pro%-N1-A06-Go2012</u>	A06	3.4 – 18.9	8.0	8.7	-0.31	0.31
N harvest index^f						
<u>NHI-N1-A06-Go2012</u>	A06	0.0 – 2.0	0.0	11.7	-0.02	0.34
<u>NHI-N1-C04b-Go2012</u>	C04b	15.5 – 39.5	23.3	3.5	-0.01	0.08
Total N uptake (kg N ha⁻¹)^h						
<u>NkgMat-N1-A06-Go2012</u>	A06	1.0 – 8.7	3.0	7.45	-5.37	0.23
N uptake efficiency^h						
<u>NupEff-N1-A06-Go2012</u>	A06	0.8 – 8.3	3.0	7.8	-0.02	0.23
<u>NupEff-N1-A06-Ei2013</u>	A06	2.0 – 5.5	3.1	41.0	0.13	0.85
<u>NupEff-N1-C04a-Go2012</u>	C04a	9.5 – 21.4	14.5	2.7	0.01	0.07
N utilization efficiency^h						
<u>NutEff-N1-A06-Go2012</u>	A06	0 – 20.9	0.0	4.2	-0.47	0.14
<u>NutEff-N1-C04a-Go2012</u>	C04a	10.5 – 21.1	14.5	2.7	-0.41	0.08

N use efficiency^h

NUE-N1-A03-Go2012	A03	66.8 – 87.1	74.8	3.7	-0.34	0.08
<u>NUE-N1-A06-Go2012</u>	A06	0.9 – 10.2	3.1	13.6	-0.78	0.40
NUE-N1-A06-Go2012	A06	42.2 – 57.0	50.0	4.0	0.38	0.06

^a Abbreviations in QTL names: EOF – end of flowering. QTL within the genomic region of the *bzh*-locus are underlined.

^b Significant at the 0.05 probability level

^c Effect of substituting the allele of parent 'Alesi-*bzh*' by the allele of parent 'H30'.

^d Proportion of phenotypic variance explained by the QTL.

^e tested in four environments.

^f Tested in five environments.

^g Tested in six environments.

^h Tested in three environments

Table S3: Correlations of seed yield, straw yield, harvest index and N efficiency related parameters. A total of 108 hybrids (54 semi-dwarf and 54 normal type) were tested at locations Einbeck (2012–2013) and Göttingen (2011–2012, 2012–2013) at low and high N supply.

		-----Low nitrogen supply-----						-----High nitrogen supply-----						
		N use efficiency	N uptake efficiency	N utilization efficiency	Seed yield (Mg ha ⁻¹) ^{a)}	Straw yield (Mg ha ⁻¹) ^{a)}	Harvest index ^{a)}	N Harvest Index	N use efficiency	N uptake efficiency	N utilization efficiency	Seed yield (Mg ha ⁻¹) ^{a)}	Straw yield (Mg ha ⁻¹) ^{a)}	Harvest index ^{a)}
N uptake efficiency	Low N supply	0.86**												
		0.78**	0.35**											
		0.94**	0.855**	0.68**										
		-0.63**	-0.26**	-0.84**	-0.45**									
		0.87**	0.56**	0.91**	0.75**	-0.91**								
		0.77**	0.42**	0.90**	0.67**	-0.82**	0.90**							
N use efficiency		0.64**	0.56**	0.50**	0.63**	-0.28**	0.49**	0.45**						
N uptake efficiency		-0.52**	-0.29**	-0.60**	-0.32**	0.77**	-0.69**	-0.61**	0.01					
N utilization eff		0.42**	0.20*	0.53**	0.40**	-0.39**	0.48**	0.52**	0.56**	-0.41**				
Seed yield (Mg ha⁻¹)	High N supply	0.49**	0.45**	0.36**	0.53**	-0.10	0.32**	0.31**	0.97**	0.20*	0.54**			
Straw yield (Mg ha⁻¹)		-0.68**	-0.40**	-0.76**	-0.55**	0.82**	-0.84**	-0.78**	-0.29**	0.84**	-0.62**	-0.12		
Harvest index		0.78**	0.51**	0.81**	0.67**	-0.78**	0.87**	0.81**	0.58**	-0.69**	0.74**	0.45**	-0.94**	
N Harvest index		0.50**	0.27**	0.60**	0.46**	-0.54**	0.60**	0.63**	0.52**	-0.49**	0.87**	0.46**	-0.74**	0.81**

^{a)} Seed yield, straw yield, and Harvest index data were extracted from Miersch et al. (2016)

*Significant at the 0.05 probability level.

**Significant at the 0.01 probability level