Supplementary Materials

Table S1. Yield, yield components, and NUtE of two N-efficient and two N-inefficient winter wheat varieties under different N levels.

N level	Cultivar	Spike number	Grain number	1000-grain weight	Grains yield	NUtE	NUpE
		($\times 10^4 \cdot hm^2$)	Per spike	(g)	($kg \cdot hm^{-2}$)	($g \cdot g^{-1}$)	($g \cdot g^{-1}$)
N8	XN509	466.62c	42.17a	34.96c	6879d	25.86d	1.01c
	AK58	495.29b	36.51c	41.03b	7419c	28.93c	0.97d
	YM49	489.99b	36.03d	47.19a	8331b	29.97b	1.05b
	ZM27	506.71a	37.80b	47.45a	9088a	31.54a	1.09a
N15	XN509	557.31b	41.57a	34.72c	8043d	25.64c	0.85c
	AK58	551.29b	36.37c	40.93b	8204c	26.00b	0.86c
	YM49	584.38a	37.40b	46.57a	10177b	30.40a	0.91b
	ZM27	536.05c	41.50a	46.40a	10321a	30.50a	0.92a

Different letters within each column indicate significant differences according to Duncan's multiple-range test (p = 0.05).

Table S2. Flag leaf morphological traits of two N-efficient and two N-inefficient winter wheat varieties under different N levels.

N level	Cultivar	FLL	FLW	FLA	FLP	FLNW	LC
		(cm)	(cm)	(cm^2)	(cm)	(cm)	
N8	XN509	15.47c	1.63d	19.04d	30.12d	1.53b	1.07d
	AK58	18.88a	1.98a	27.91a	36.60a	1.72a	1.15c
	YM49	18.67a	1.92b	27.09b	36.73b	1.52b	1.26a
	ZM27	17.65b	1.81c	24.04c	34.30c	1.50c	1.21b
N15	XN509	15.42c	1.63d	18.77d	30.17d	1.49b	1.09d
	AK58	19.32a	2.01a	29.25a	38.19a	1.79a	1.12c
	YM49	19.22a	1.95b	28.22b	37.65b	1.57b	1.24a
	ZM27	17.76b	1.81c	24.41c	34.71c	1.47c	1.23b

Different letters within each column indicate significant differences according to Duncan's multiple-range test (p = 0.05).

Table S3. The leaf angle vertical distribution of two N-efficient and two N-inefficient winter wheat varieties under different N levels.

N level	Cultivar	BA (°)			OA (°)			DA (°)		
		UL	ML	LL	UL	ML	LL	UL	ML	LL
N8	XN509	13.75d	16.97d	19.08d	20.96b	24.2±b	28.33b	7.21b	7.23b	9.25b
	AK58	20.16a	23.52a	23.04a	48.40a	52.76a	52.05a	28.24a	29.24a	29.01a
	YM49	16.96c	17.55c	20.90b	19.18c	20.88d	25.21c	2.22c	3.33c	4.31c
	ZM27	17.65b	19.24b	20.02c	20.20b	22.48c	23.53d	2.55c	3.24c	3.51d
N15	XN509	14.09c	19.03d	21.54c	22.34b	27.17b	30.58b	8.25bb	8.14b	9.04b
	AK58	22.52a	24.15a	23.83a	112.7a	114.3a	114.8a	90.25a	90.15a	91.05a
	YM49	18.08b	20.42c	22.60b	20.29d	24.75d	27.63c	2.21c	4.33c	5.03c
	ZM27	18.20b	21.39b	22.61b	21.42c	25.54c	27.13c	3.22c	4.15c	4.52d

Different letters within each column indicate significant differences according to Duncan's multiple-range test (p = 0.05).

Table S4. P_n, T_r, and WUE_{inst} vertical distribution of two N-efficient and two N-inefficient winter wheat varieties under different N levels.

N level	Cultivar	P_n (μmol^{-2}·s^{-1})			T_r (g·m^{-2}·h^{-1})			WUE_{inst}		
		UL	ML	LL	UL	ML	LL	UL	ML	LL
N8	XN509	14.87d	13.18d	7.22d	3.36b	3.91c	0.64d	4.43c	3.37c	11.19a
	AK58	15.77c	17.62c	13.86a	4.54a	4.94a	2.94a	3.48d	3.59c	4.70c
	YM49	25.29b	23.51b	12.19b	5.20c	5.05a	2.48c	4.86b	4.66b	4.94b
	ZM27	27.38a	24.54a	11.29c	5.00b	4.61b	2.67b	5.48a	5.34a	4.22d
N15	XN509	16.78d	14.01d	6.02b	4.19b	4.07c	0.69c	4.01d	3.45c	8.66a
	AK58	22.80c	15.15c	4.55c	4.61a	4.30c	0.76b	4.94c	3.53c	6.00b
	YM49	29.14b	25.20b	7.24a	5.74d	4.81b	1.65a	5.08b	5.23a	4.39c
	ZM27	30.29a	26.29a	7.25a	5.72c	5.97a	1.64a	5.30a	4.41b	4.39c

Different letters within each column indicate significant differences according to Duncan's multiple-range test (p = 0.05).

Table S5. K_L, K_N, and K_N/K_L of two N-efficient and two N-inefficient winter wheat varieties under different N levels.

N level	Cultivar	K_L	K_N	K_N/K_L
N8	XN509	0.4712a	0.1471b	0.3121b
	AK58	0.4018c	0.1071c	0.3329b
	YM49	0.3277c	0.1644c	0.5017c
	ZM27	0.3431b	0.1837c	0.5353c
N15	XN509	0.4361c	0.1167c	0.2675c
	AK58	0.5162b	0.1825b	0.3535a
	YM49	0.3615b	0.2207b	0.6105a
	ZM27	0.3393 c	0.2192b	0.6462a

Different letters within each column indicate significant differences according to Duncan's multiple-range test (p = 0.05).