

Table S1 Variance components as percent of total sum of components using Eq. (1) based on years 1995–2021. NUE for grain peas were not listed as they received no regular nitrogen fertilizer.

	NYLD								Mean	GPC/GOC								Mean	GYLD/OYLD								Mean		
G	4.0	1.5	1.4	1.3	2.4	0.6	3.7	3.4	2.3	23.8	22.4	5.2	2.8	11.3	2.5	7.3	18.0	20.9	12.7	9.2	7.4	1.6	2.1	1.6	1.2	3.4	3.3	3.6	3.7
GxY	0.9	1.6	1.4	0.5	1.0	0.4	1.1	1.2	1.0	1.6	1.8	1.1	0.9	1.7	0.9	0.7	1.9	2.4	1.4	1.5	2.5	1.4	0.6	1.3	0.5	1.6	1.8	1.2	1.4
GxL	0.4	1.5	3.3	2.3	2.9	0.5	1.0	2.0	1.7	1.3	1.3	2.4	1.2	3.9	0.2	0.6	0.9	1.5	1.5	0.9	2.5	3.3	1.4	3.4	0.8	1.4	1.7	1.6	1.9
Res	12.1	5.9	5.0	5.0	3.6	6.9	9.1	7.0	6.8	9.6	7.0	3.4	3.6	4.7	8.1	6.3	9.3	10.7	7.0	10.4	7.7	4.1	4.2	3.7	5.5	9.4	9.8	7.0	6.9
Y	9.1	0.0	3.8	3.2	13.2	5.3	9.6	9.9	6.8	7.0	8.3	11.3	11.7	10.3	25.8	10.8	12.6	13.3	12.3	14.8	0.0	11.4	9.2	15.0	14.4	18.3	19.7	13.5	12.9
L	18.3	23.9	33.3	35.0	31.5	24.7	27.1	25.7	27.4	19.3	5.7	18.8	19.3	16.1	7.3	26.0	18.7	10.3	15.7	23.1	25.5	32.3	33.3	30.5	24.5	20.1	16.6	20.2	25.1
YxLxT	55.1	65.7	51.8	52.7	45.5	61.6	48.3	50.9	53.9	37.3	53.6	57.8	60.5	52.0	55.1	48.3	38.7	40.8	49.4	40.1	54.4	46.0	49.1	44.6	53.1	45.8	47.0	53.0	48.1
GxE	1.3	3.0	4.7	2.8	3.9	0.9	2.1	3.1	2.7	2.9	3.1	3.5	2.1	5.7	1.2	1.3	2.8	4.0	2.9	2.4	5.0	4.7	2.0	4.6	1.3	3.0	3.5	2.8	3.3
E	82.5	89.6	88.9	90.9	90.2	91.6	85.1	86.4	88.2	63.6	67.6	87.9	91.5	78.4	88.3	85.1	70.0	64.5	77.4	78.0	79.8	89.6	91.6	90.0	92.0	84.1	83.3	86.7	86.1
	WW	WWORG	RW_Hyb	RW_Pop	SW	SB	WOSR	PEAS		WW	WWORG	RW_Hyb	RW_Pop	SW	SB	WOSR GPC	WOSR GOC			WW	WWORG	RW_Hyb	RW_Pop	SW	SB	WOSR GYLD	WOSR OYLD	PEAS	

	NYLD _{NUE}								Mean	GYLD/OYLD _{NUE}								Mean
G	1.7	0.6	0.3	0.3	1.6	0.5	1.0	0.9	3.9	2.6	0.4	0.6	1.0	0.8	0.9	1.6	1.5	
GxY	0.4	0.7	0.5	0.1	0.9	0.3	0.3	0.7	0.6	1.1	0.4	0.1	0.9	0.3	0.4	0.8	0.6	
GxL	0.2	0.9	1.0	0.8	2.4	0.3	0.3	0.7	0.4	1.8	1.1	0.5	2.5	0.5	0.4	0.8	1.0	
Res	5.7	3.0	1.7	1.4	2.8	5.1	2.8	2.0	4.8	3.9	1.3	1.1	2.5	3.6	2.7	4.8	3.1	
Y	4.9	1.0	1.6	2.2	18.3	3.9	4.1	4.2	6.2	0.0	0.3	0.3	14.5	12.8	4.5	5.1	5.5	
L	40.8	67.3	30.3	23.3	25.2	36.9	15.8	19.7	45.2	70.6	34.5	28.8	28.4	38.6	14.6	25.6	35.8	
YxLxT	46.4	26.4	64.6	71.7	48.7	53.0	75.7	44.7	38.7	20.0	62.0	68.6	50.2	43.4	76.4	61.3	52.6	
GxE	0.6	1.6	1.5	1.0	3.3	0.6	0.6	1.3	1.1	2.9	1.5	0.6	3.4	0.9	0.9	1.6	1.6	
E	92.0	94.8	96.5	97.3	92.3	93.8	95.6	94.6	90.2	90.6	96.8	97.7	93.1	94.8	95.6	91.9	93.8	
	WW	WWORG	RW_Hyb	RW_Pop	SW	SB	WOSR		WW	WWORG	RW_Hyb	RW_Pop	SW	SB	WOSR GYLD	WOSR OYLD		

WW Winter wheat; WWORG Winter wheat under organic testing regimen; WR Winter rye, *Hyb* hybrid and *Pop* population varieties; SW spring wheat; SB Spring barley; WSOR Winter oil seed rape; PEAS Grain peas; NYLD Nitrogen yield in grain; GPC Grain protein concentration; GOC Grain oil concentration; GYLD Grain yield; OYLD Oil yield; GYLD_{NUE} Nitrogen use efficiency of nitrogen yield in grain ($GYLD_{NUE} = NYLD/N_{avail}$); GYLD_{NUE} Nitrogen use efficiency of grain yield ($GYLD_{NUE} = GYLD/N_{avail}$); OYLD_{NUE} Nitrogen use efficiency of oil yield ($OYLD_{NUE} = OYLD/N_{avail}$); N_{avail} : N rate + Nmin; G Genotype; Y Year; L Location; YxLxT Interaction of trials within YxL; Res Residual; $G \times E$ Genotype $\times$ environment ($G \times E = G \times Y + G \times L$); E Environment ($E = Y + L + Y \times L \times T$);