Note S1

We conducted a literature review to retrieve information about N_2O emissions and NO_3^- leaching in the U.S. Corn Belt. The search was conducted through Web of Science®. The 31 of June 2024 was selected as a cut-off date, after which literature searches were no longer conducted The implemented keywords were: “fertilizer”, “nitrogen” OR “N“, “agriculture”, “nitrous oxide”, “emissions”, “nitrate”, and “leaching”. The selection criteria were: (i) the experiment was conducted in the studied states within the United States of America (Iowa, Illinois, Indiana, Minnesota, Missouri, North Dakota, Nebraska, and Wisconsin); (ii) the experiments were performed in field conditions; (iii) only corn-based systems were considered; (iv) the implemented N rates were between 50 kg N ha^{-1} and 300 kg N ha^{-1} because N_2O emissions and NO_3^- leaching were calculated at the E[AONR], E[EONR], and the 0.3 quantile of the EONR; and (v) manure were not included because of uncertainty and variability in nutrient composition. Out of the retrieved articles, a total of 31 studies were considered to summarize N_2O emissions and NO_3^- leaching in the U.S. Corn Belt (**Table S3**).

Supplementary Tables

Table S1. Prior probability distributions of the parameters in the quadratic plateau models fitted to the relationship between grain yield and nitrogen rates. Inside the parenthesis for the hyperparameters column, the left and the right numbers indicate the shape and the rate of the distribution, respectively.

State	Parameter	Probability Distribution	Hyperparameters
Iowa	β_0	gamma	(10.89, 0.0015)
	β_1		(3.26, 0.0467)
	β_2		(1.5, 10.00)
	σ_ε		(3.75, 0.0025)
Illinois	β_0	gamma	(9.389, 0.0014)
	β_1		(2.82, 0.043)
	β_2		(0.96, 8.00)
	σ_ε		(3.75, 0.0025)
Indiana	β_0	gamma	(10.43, 0.0015)
	β_1		(2.64, 0.039)
	β_2		(1.22, 8.75)
	σ_ε		(3.75, 0.0025)
Minnesota	β_0	gamma	(9.041, 0.0015)
	β_1		(2.16, 0.045)
	β_2		(1.025, 11.39)
	σ_ε		(6.51, 0.0042)
Missouri	β_0	gamma	(13.68, 0.0021)
	β_1		(1.98, 0.0415)
	β_2		(1.20, 7.083)
	σ_ε		(8.026, 0.0044)

Table S1 (continued).

State	Parameter	Probability Distribution	Hyperparameters
North Dakota	β_0	gamma	(13.26, 0.0018)
	β_1		(0.914, 0.0307)
	β_2		(0.916, 8.33)
	σ_ε		(9.17, 0.0042)
Nebraska	β_0	gamma	(20.28, 0.00205)
	β_1		(1.838, 0.0416)
	β_2		(0.89, 8.14)
	σ_ε		(8.105, 0.0043)
Wisconsin	β_0	gamma	(20.17, 0.00217)
	β_1		(1.703, 0.0382)
	β_2		(1.071, 7.1428)
	σ_ε		(5.266, 0.00315)

Table S2. Reason justifying why the sites in this table were not included to analyze nitrogen reductions. AONR stands for the agronomic optimum nitrogen rate, E[AONR] is the expected value of the AONR. N rate represents the nitrogen fertilization rate applied to maize crop at planting. EONR represents the economic optimum nitrogen rate. $\widehat{R}$ (“R hat”) indicates the Gelman-Rubin diagnostic. The column site indicates the number of the experiment in the original dataset.

State	Site	Reason
Illinois	T3	E[AONR] > max(N rate)
Minnesota	T39	E[AONR] > max(N rate)
Missouri	T25	E[AONR] > max(N rate) and $\widehat{R}$ >1.02 for EONR
Missouri	T26	E[AONR] > max(N rate) and $\widehat{R}$ >1.02 for EONR
North Dakota	T12	E[AONR] > max(N rate) and $\widehat{R}$ >1.02 for EONR
North Dakota	T27	$\widehat{R}$ >1.02 for EONR
North Dakota	T28	$\widehat{R}$ >1.02 for EONR
North Dakota	T44	$\widehat{R}$ >1.02 for AONR and EONR
North Dakota	T45	$\widehat{R}$ >1.02 for AONR and EONR
Nebraska	T13	E[AONR] > max(N rate) and $\widehat{R}$ >1.02 for EONR
Nebraska	T29	E[AONR] > max(N rate) and $\widehat{R}$ >1.02 for EONR
Nebraska	T30	$\widehat{R}$ >1.02 for AONR and EONR
Nebraska	T47	$\widehat{R}$ >1.02 for AONR and EONR
Wisconsin	T31	$\widehat{R}$ >1.02 for EONR
Wisconsin	T32	E[AONR] > max(N rate) and $\widehat{R}$ >1.02 for EONR
Wisconsin	T48	$\widehat{R}$ >1.02 for EONR
Wisconsin	T49	$\widehat{R}$ >1.02 for AONR and EONR

Table S3. Descriptive statistics for the retrieved studies addressing N_2O emissions and NO_3^- leaching in the United States Corn Belt. The last column indicates the minimum (Min), 0.25 quantile (Q0.25), the mean, the variance, 0.75 quantile (Q0.75), and the maximum value of N_2O emissions and NO_3^- leaching across all the studies.

Reference	Number of Obs.	State	N_2O – N (kg ha^{-1})		N_2O – N (kg ha^{-1})					
			Mean	Variance	Min	Q0.25	Mean	Variance	Q0.75	Max
Adviento-Borbe et al. (2007)[1]	10	NE	3.71	5.71	0.28	1.29	3.93	11.65	5.37	16.26
Fujinuma et al. (2011)[2]	6	MN	0.90	0.24						
Maharjan and Venterea (2013)[3]	3	MN	2.43	0.82						
Maharjan et al. (2014)[4]	3	MN	0.34	0.01						
Parkin and Hatfield (2010)[5]	2	IA	6.14	1.57						
Phillips et al. (2009)[6]	2	ND	0.48	0.01						
Smith et al. (2011)[7]	8	IN	2.82	0.22						
Venterea et al. (2010)[8]	12	MN	1.59	0.65						
Hernandez-Ramirez et al. (2009)[9]	4	IN	5.65	1.08						
Johnson et al. (2010)[10]	9	MN	5.29	0.77						
Mitchell et al. (2013)[11]	4	IA	4.49	1.00						
Omonode and Vyn (2013)[12]	8	IN	4.09	29.47						
Johnson II et al. (2024)[13]	2	IA	1.01	0.12						
Preza-Fontes et al. (2023)[14]	9	IL	10.40	3.29						

Table S3 (continued).

Reference	Number of Obs.	State	$NO_3^- - N$ (kg ha^{-1})		$NO_3^- - N$ (kg ha^{-1})					
			Mean	Variance	Min	Q0.25	Mean	Variance	Q0.75	Max
Bakhsh et al. (2007)[15]	5	IA	10.1	48						
Bakhsh et al. (2010)[16]	10	IA	11.4	55						
Helmers et al. (2012)[17]	28	IA	46.7	403						
Jaynes (2013)[18]	6	IA	32.3	127						
Jaynes et al. (2001)[19]	6	IA	47.5	107						
Kucharik and Brye (2003)[20]	10	WI	56.1	3161						
Maharjan et al. (2014)[4]	3	MN	25.8	19						
Prunty and Greenland (1997)[21]	4	ND	47.2	2822						
Randall et al. (2003)[22]	24	MN	36.0	1209	0.02	14.0	34.8	1005	47.7	201.1
Randall and Vetsch (2005)[23]	24	MN	17.4	256						
Sexton et al. (1996)[24]	12	MN	60.0	1831						
Walters and Malzer (1990)[25]	24	MN	49.2	1726						
Kalita et al. (2006)[26]	21	IL	24.8	330						
O'Brien et al. (2022)[27]	10	IA	14.8	149						
Preza-Fontes et al. (2023)[14]	3	IL	21.9	24						
Johnson II et al. (2024)[13]	2	IA	26.1	283						
Gentry et al. (2023)[28]	6	IL	27.8	49						

Supplementary Figures

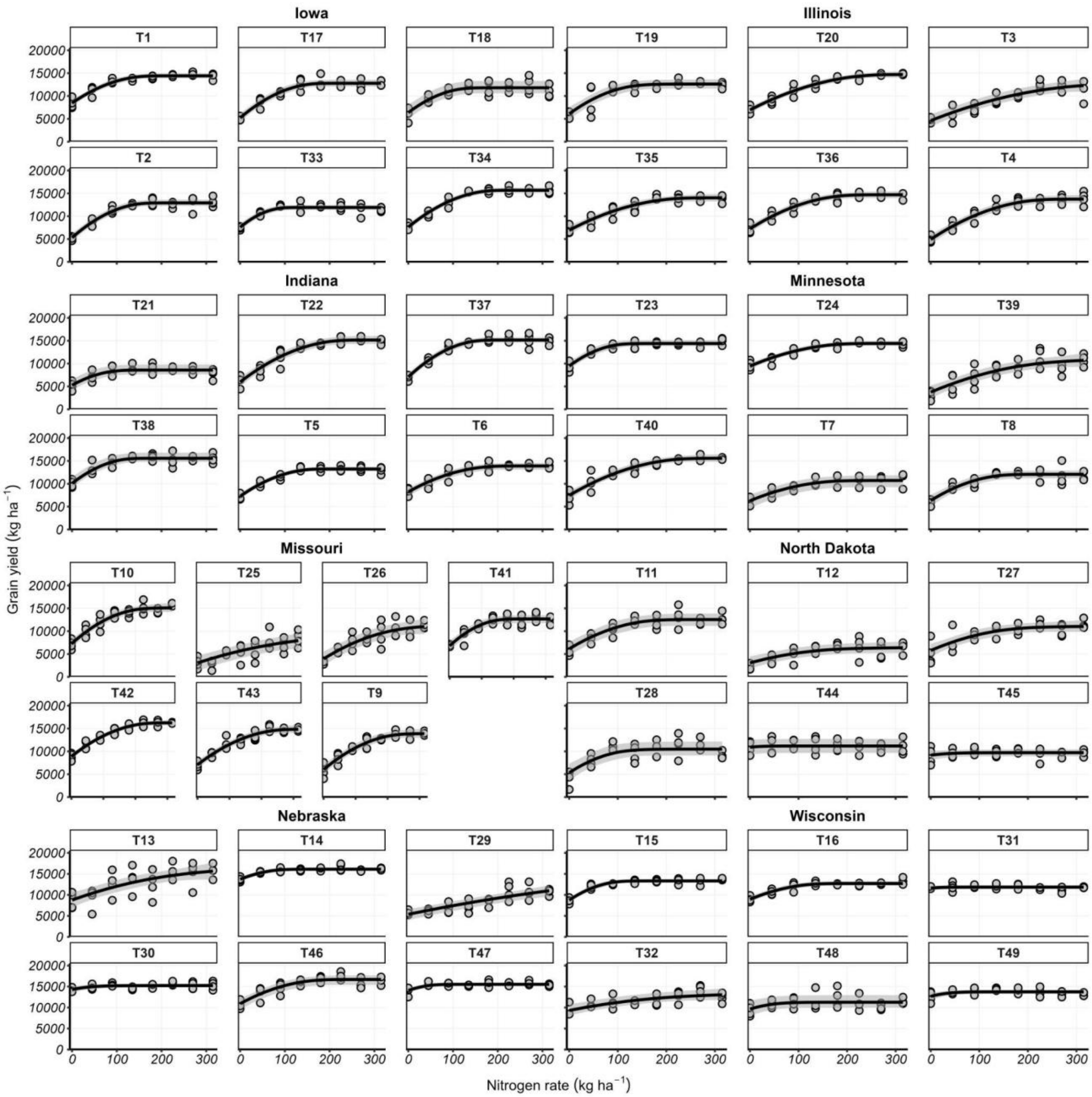

Fig. S1. Relationship between maize grain yield (*y*) and nitrogen rate (*x*) in each of the studied sites. The solid lines represent the expected grain yield at different nitrogen rates. The shadow areas indicate the 95% credible interval of the posterior predictive distributions. The label in each plot indicates the number of the trial in the original dataset.

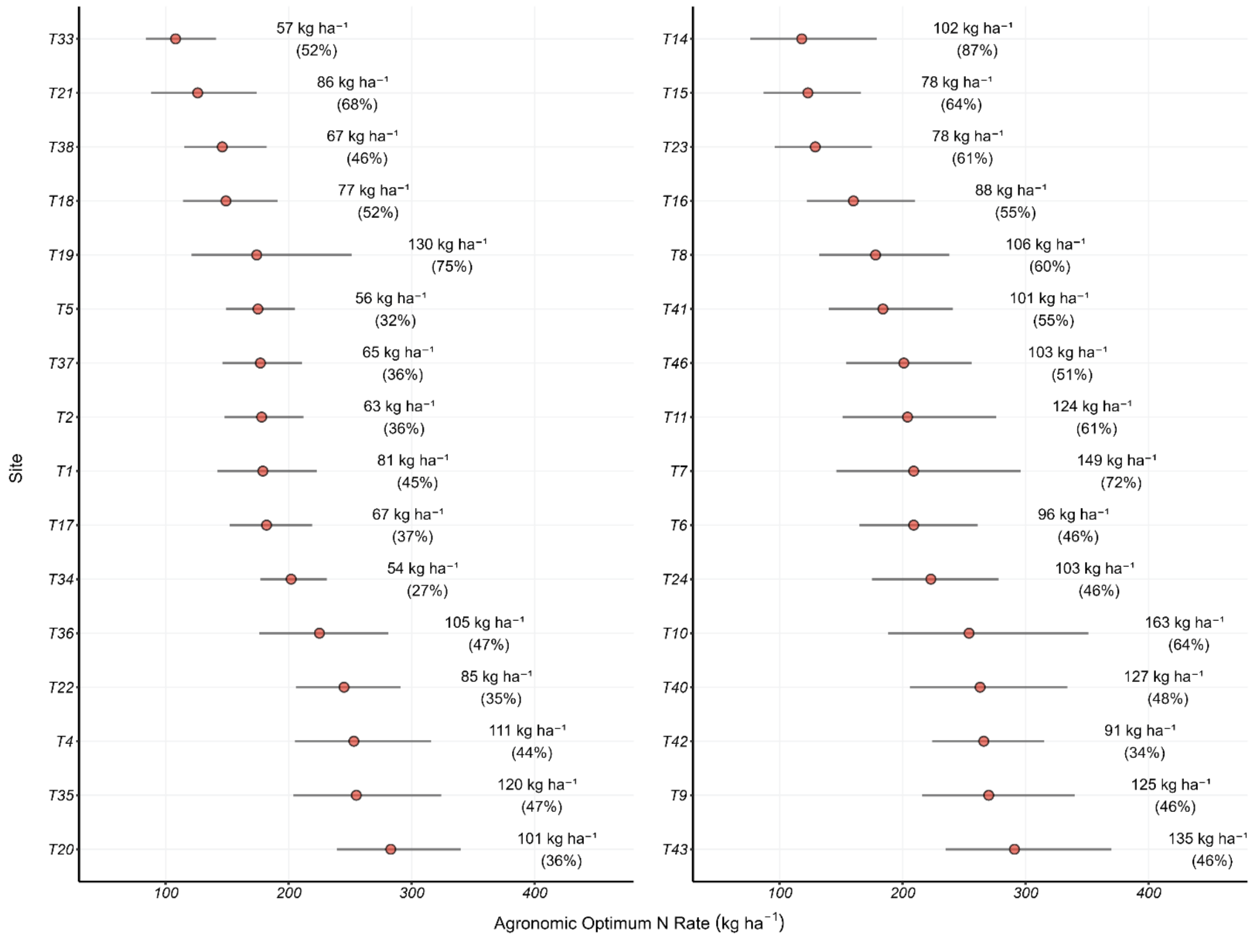

Fig. S2. Summary of the agronomic optimum nitrogen rate (AONR) for each of the selected sites. Circles indicate the expected value of the distribution (E[AONR]), the horizontal bars and upper values on the right indicate the 95% credible interval of the AONR, and the lower values, between parentheses, on the right indicate the proportion of the uncertainty with respect to E[AONR]. The labels in the *y* axis indicate the number of the trial in the original dataset.

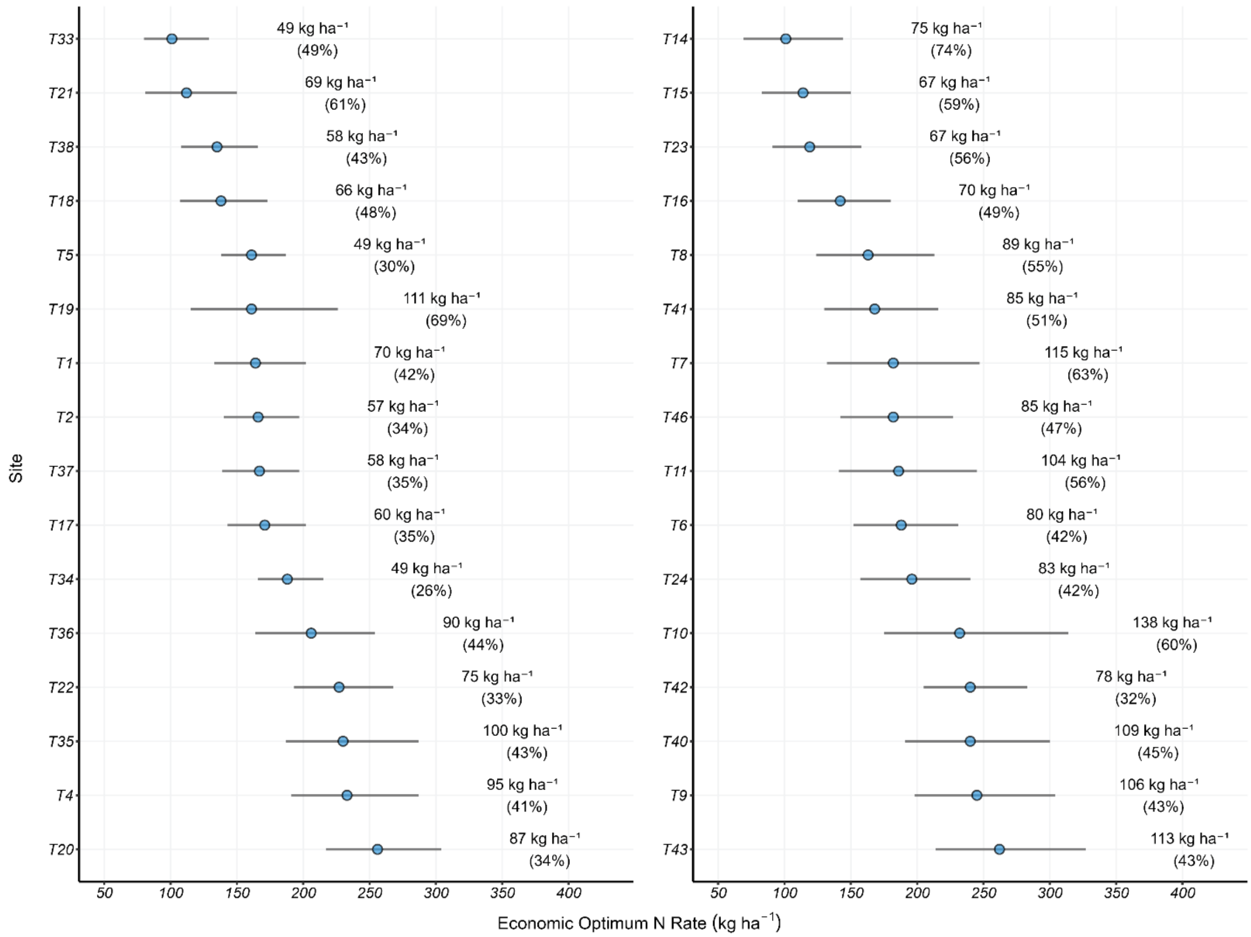

Fig. S3. Summary of the economic optimum nitrogen rate (EONR) for each of the selected sites. Circles indicate the expected value of the distribution (E[EONR]), the horizontal bars and upper-level values on the right indicate the 95% credible interval of the EONR, and the lower-level values, between parentheses, on the right indicate the proportion of the uncertainty with respect to E[EONR]. The labels in the *y* axis indicate the number of the trial in the original dataset.

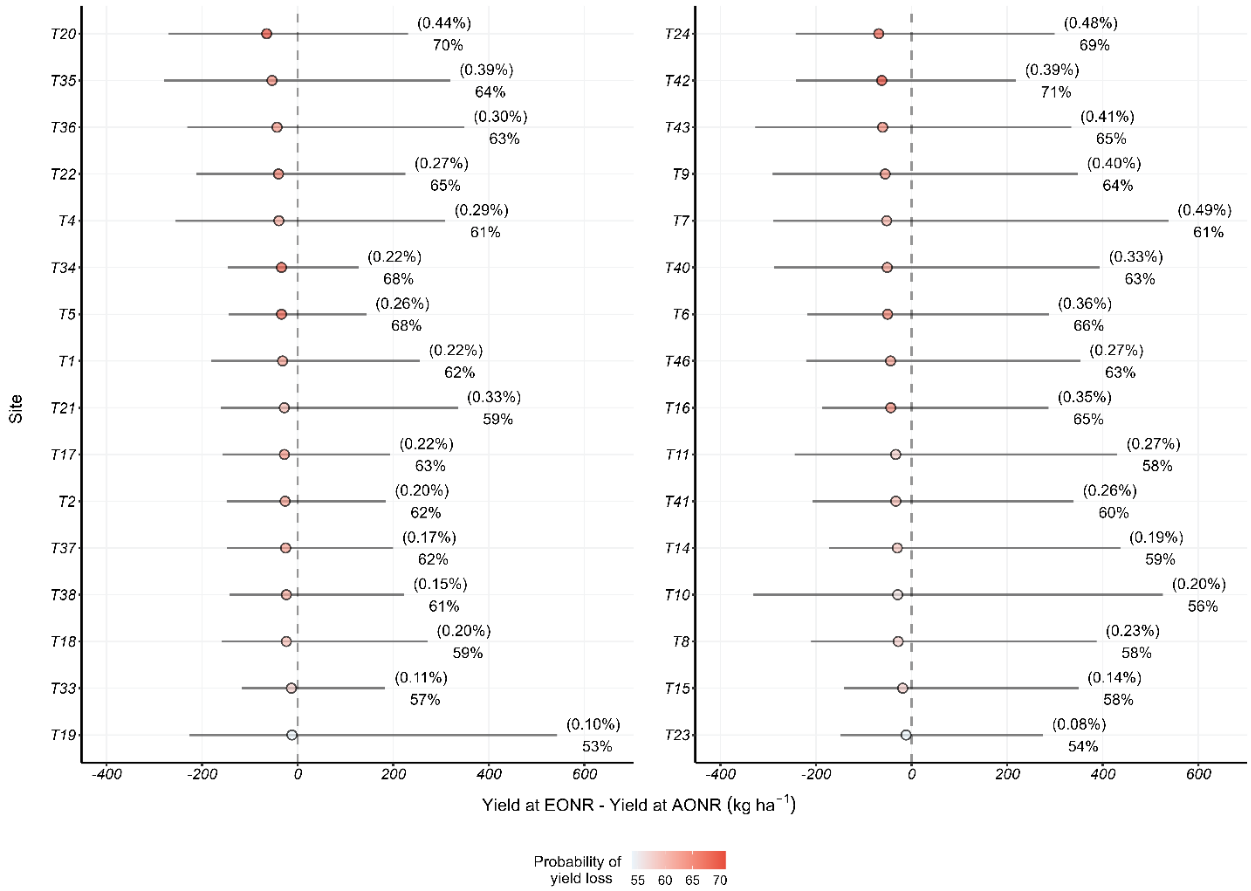

Fig. S4. Yield loss and its probability when reducing the nitrogen rate from the expected value of the agronomic optimum nitrogen rate probability distribution (E[AONR]) to expected value of the economic optimum nitrogen rate probability distribution (E[EONR]). This corresponds to Phase I of nitrogen reductions. Circles indicate the expected yield loss, the horizontal bars and indicate the 95% credible interval of the yield loss estimation. The upper-level values, between parentheses, on the right indicate the proportion of yield loss with respect to E[AONR] and the lower-level values on the right and circle colors indicate the probability associated to each yield loss estimation. The labels in the *y* axis indicate the number of the trial in the original dataset.

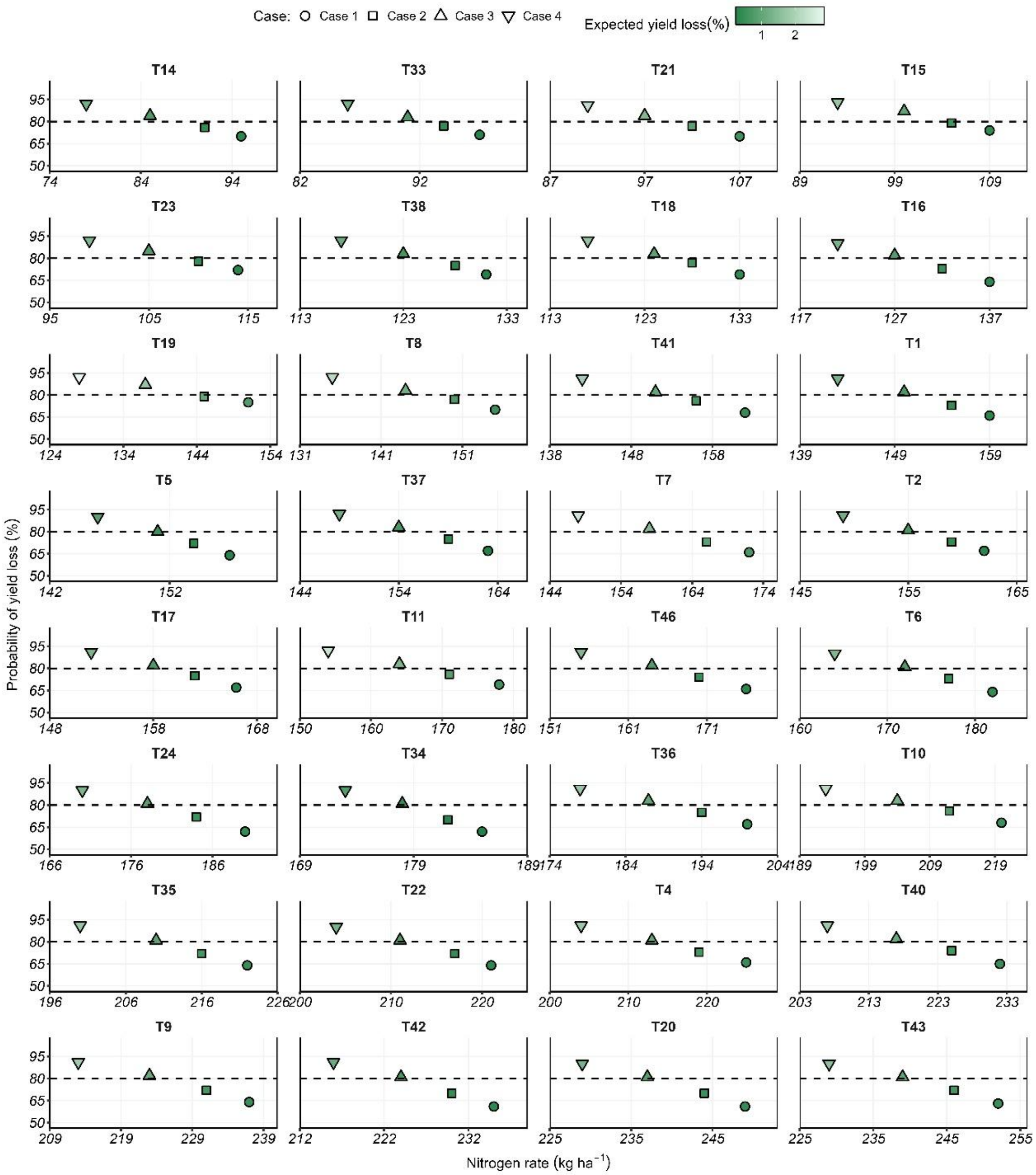

Fig. S5. Probability of yield loss and expected yield loss with respect to yield at the economic optimum nitrogen rate (EONR) (Phase II) in a given quadratic plateau model within each site for each case of nitrogen fertilization reduction. Cases 1, 2, 3, and 4 represent the 0.4, 0.3, 0.2, and 0.1 quantiles of the EONR probability distribution, respectively. The label in each plot indicates the number of the trial in the original dataset.

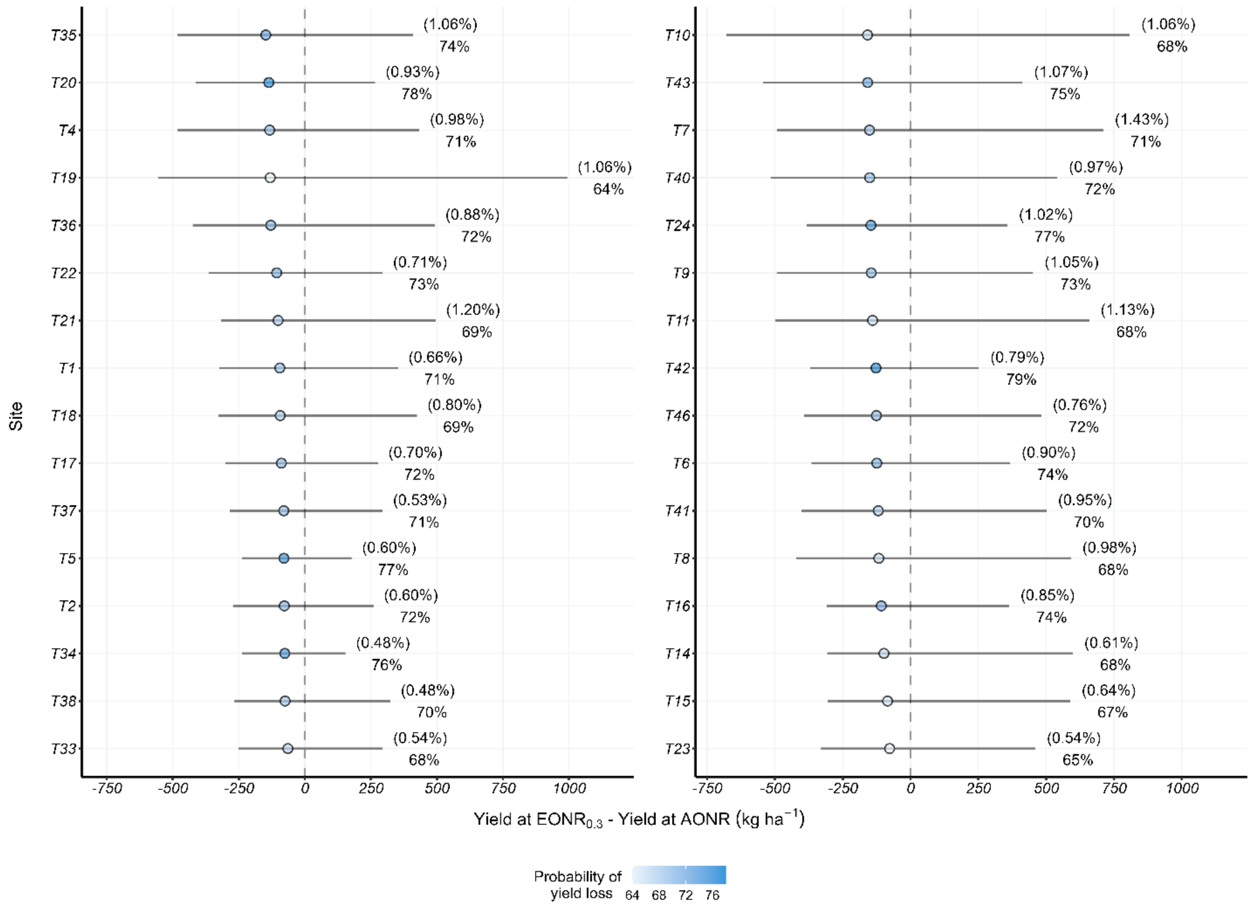

Fig. S6. Yield loss and its probability when reducing the nitrogen rate from the expected value of the agronomic optimum nitrogen rate probability distribution (E[AONR]) to the 0.3 quantile of the economic optimum nitrogen rate probability distribution ($EONR_{0.3}$). This corresponds to the total nitrogen fertilization reductions Phases I and II. Circles indicate the expected yield loss, the horizontal bars and indicate the 95% credible interval of the yield loss estimation. The upper-level values, between parentheses, on the right indicate the proportion of yield loss with respect to E[AONR] and the lower-level values on the right and circle colors indicate the probability associated to each yield loss estimation. The labels in the *y* axis indicate the number of the trial in the original dataset.

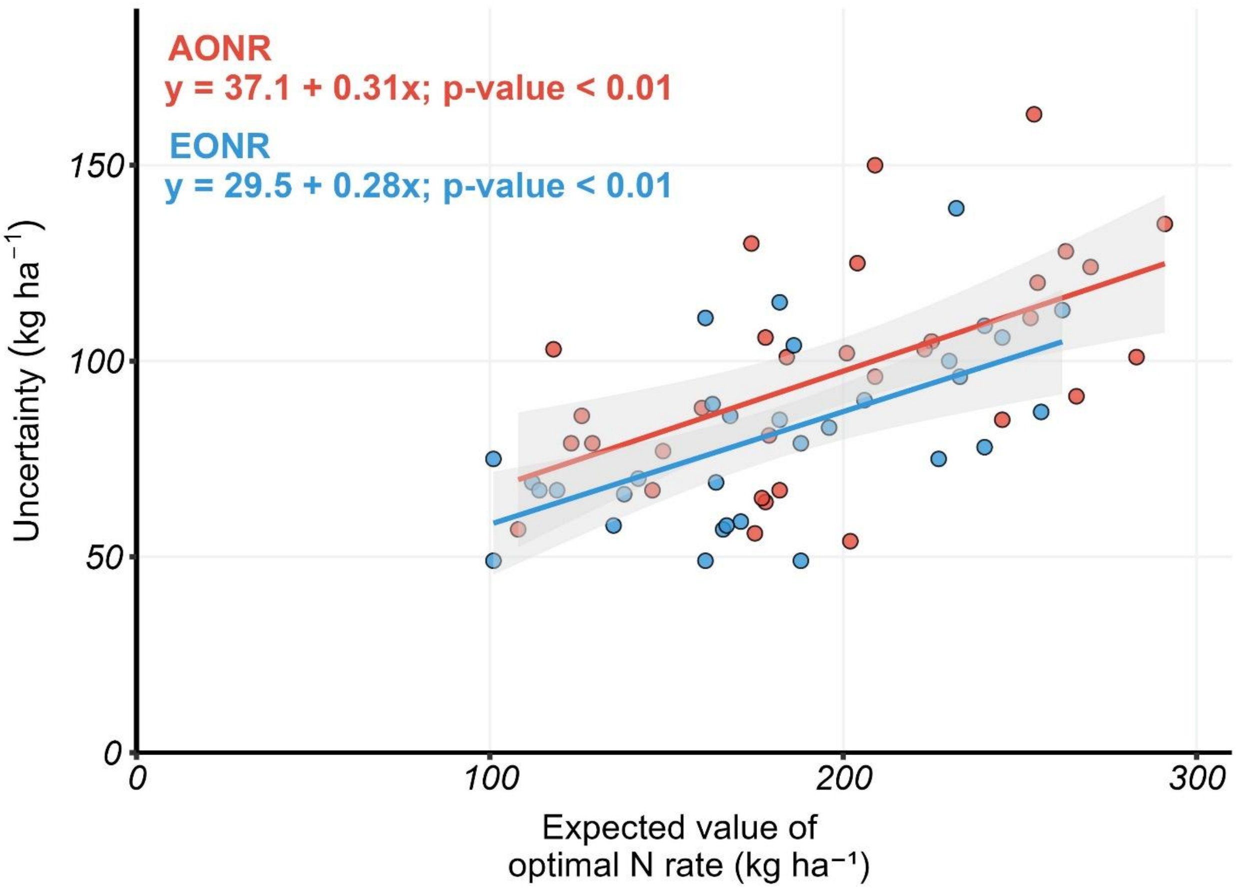

Fig. S7. Relationship between the expected value of the optimal nitrogen rates (AONR and EONR) and their associated uncertainties. Solid line is the least square estimation of the regression between the dependent (*y*) and independent (*x*) variables in this plot. Shadow area represents the 95% confidence interval of the regression line. P-values < 0.01 indicate that the slopes were different from zero for $\alpha = 0.01$.

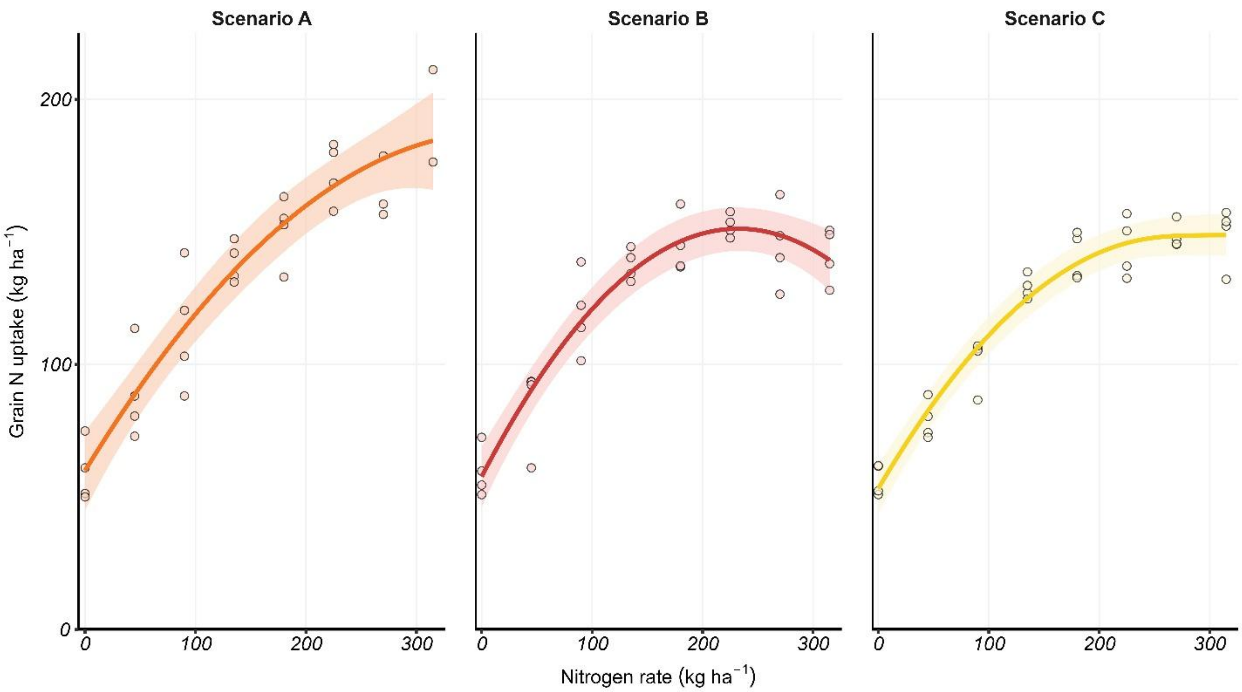

Fig. S8. Relationship between grain nitrogen uptake (*y*) and nitrogen rate (*x*) in each of the selected scenarios. The solid lines represent the expected nitrogen uptake at different nitrogen rates. The shadow areas indicate the 95% credible interval of the posterior predictive distributions.

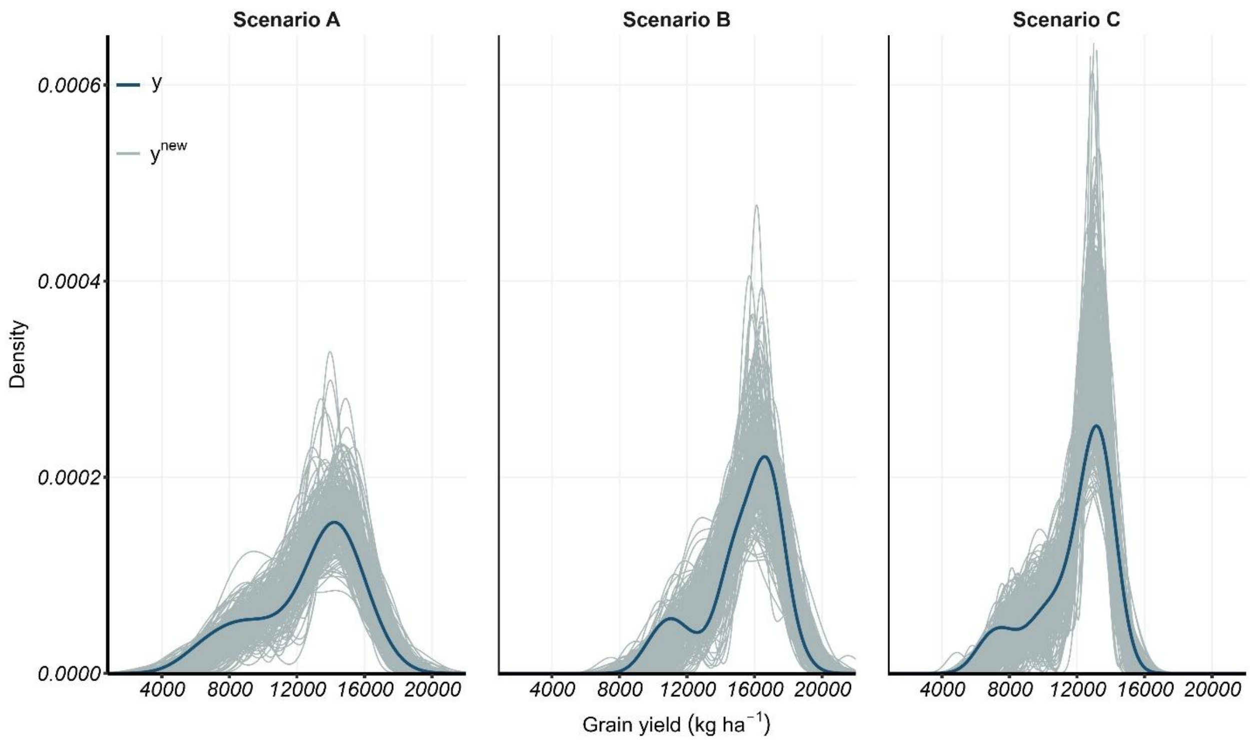

Fig. S9. Posterior predictive distributions for the models fitted to the maize grain yield versus nitrogen rate relationship in each of the selected scenarios. The blue lines are the distribution of the observed values of grain yield. The gray lines are two hundred curves representing the distribution of 32 observations (total number of observations in each scenario) randomly sampled from the posterior predictive distributions for grain yield.

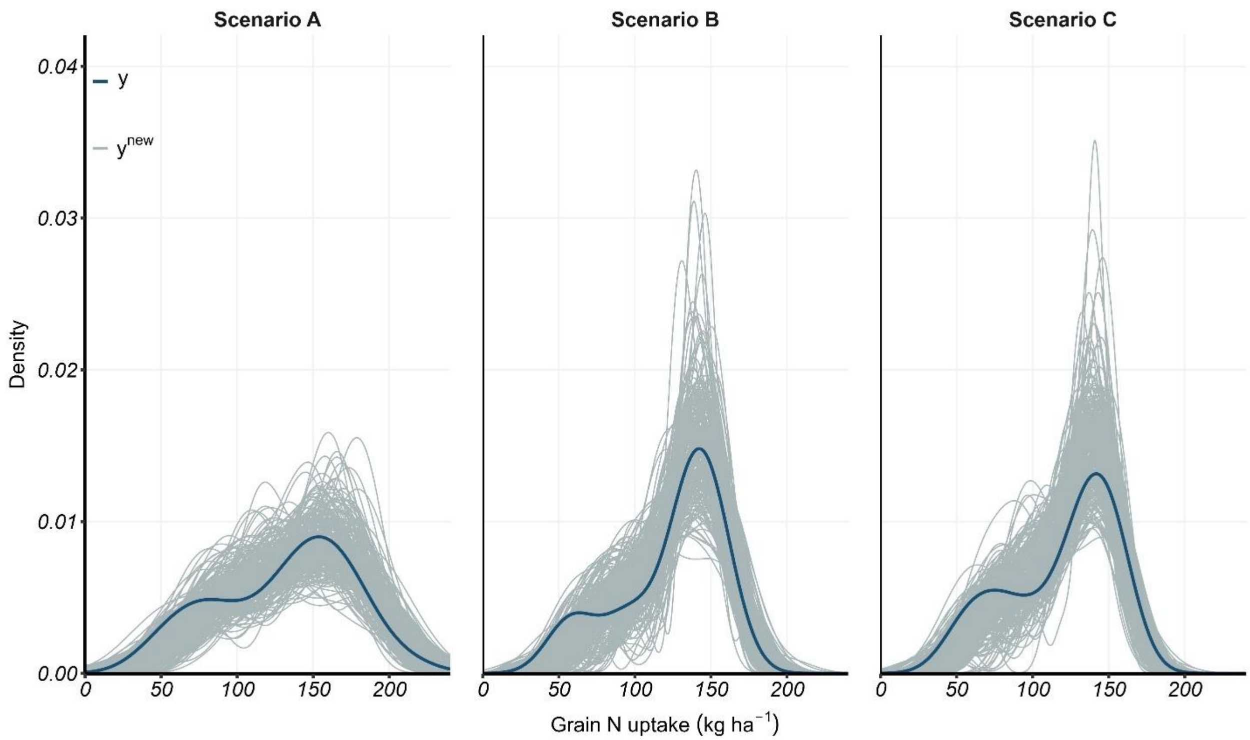

Fig. S10. Posterior predictive distributions for the models fitted to the grain nitrogen uptake versus nitrogen rate relationship in each of the selected scenarios. The blue lines are the distribution of the observed values of grain nitrogen uptake. The gray lines are two hundred curves representing the distribution of 32 observations (total number of observations in each scenario) randomly sampled from the posterior predictive distributions for grain nitrogen uptake.

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