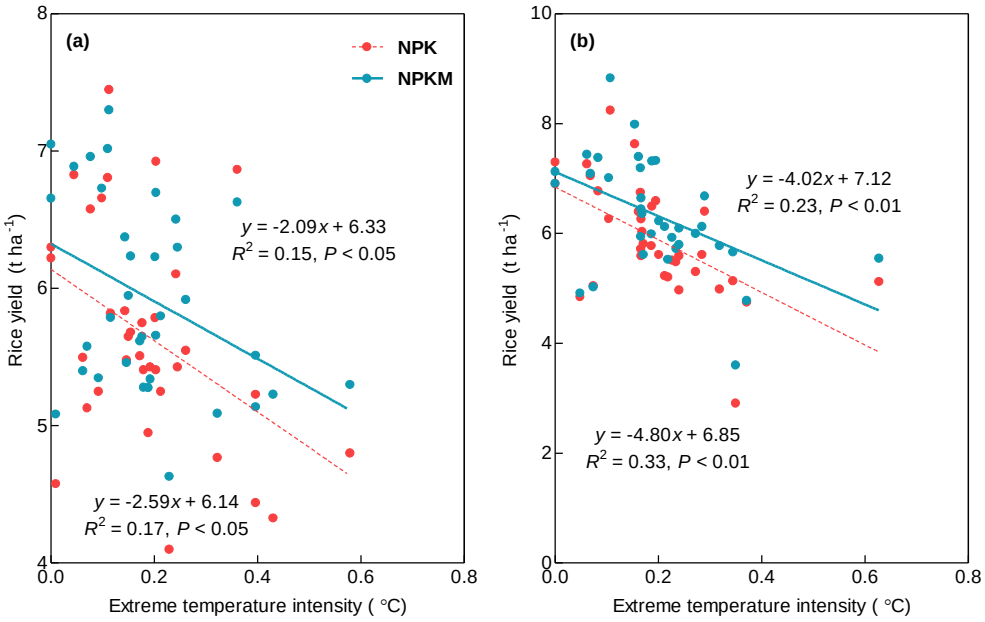
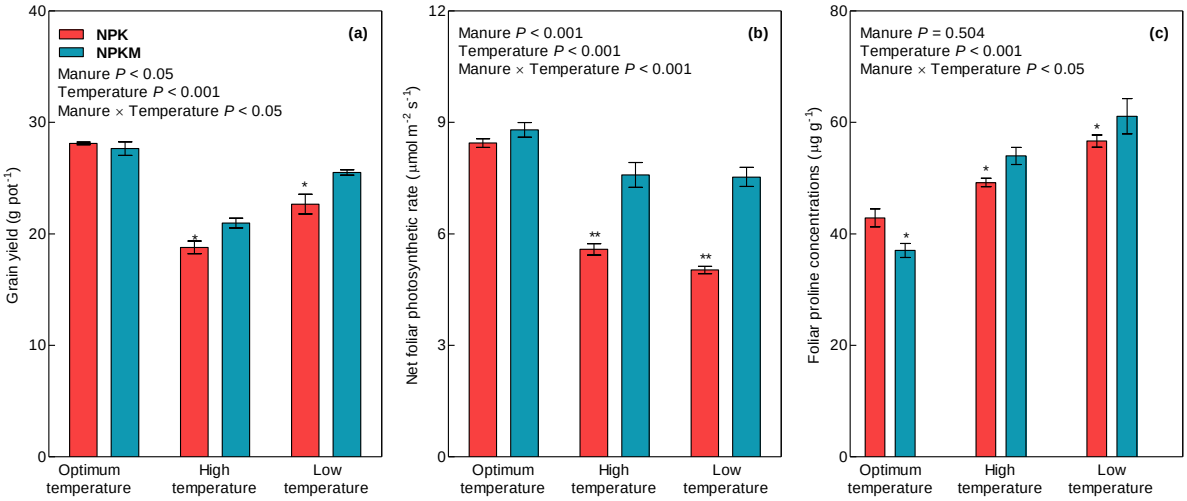
Supporting information for

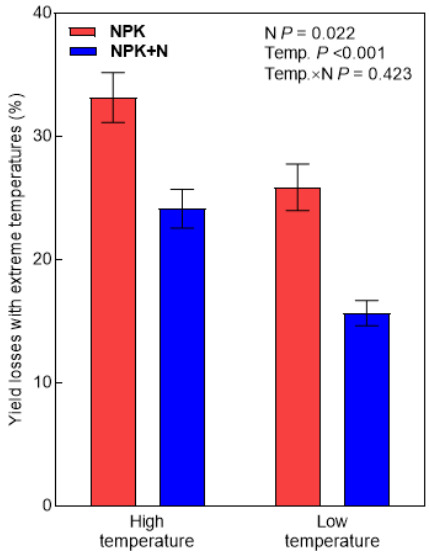
Manure amendment can reduce rice yield loss under extreme temperatures



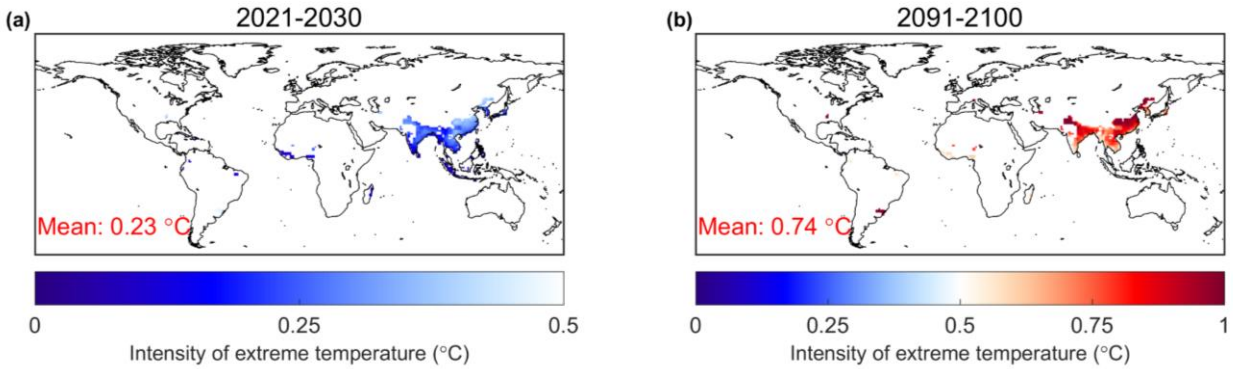
Supplementary Fig. 1: Rice yields in a long-term field experiment as affected by manure amendment and extreme temperatures. Correlation between rice yield and intensity of temperature extremes in the early rice season (*n*=35) (**a**) and the late rice season (*n*=35) (**b**) with inorganic fertilizer (NPK) and a combination of manure and inorganic fertilizer (NPKM).



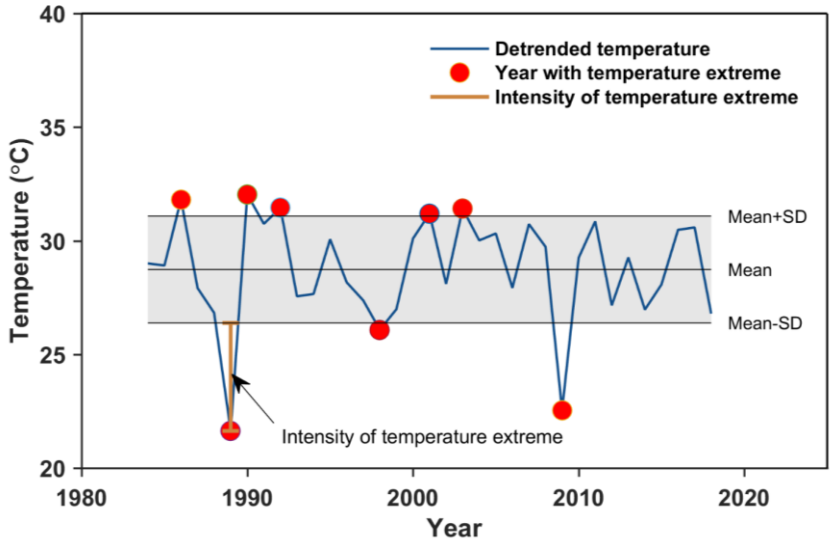
Supplementary Fig. 2: Rice yield, net foliar photosynthetic rates, and foliar proline concentrations as affected by manure amendment and temperatures in a pot experiment. a Rice yield (*n*=5), **b** net foliar photosynthetic rate (*n*=4), **c** foliar proline concentration (*n*=4). * and ** denote significant effects at $P < 0.05$ and $P < 0.01$, respectively. Error bars represent standard errors.



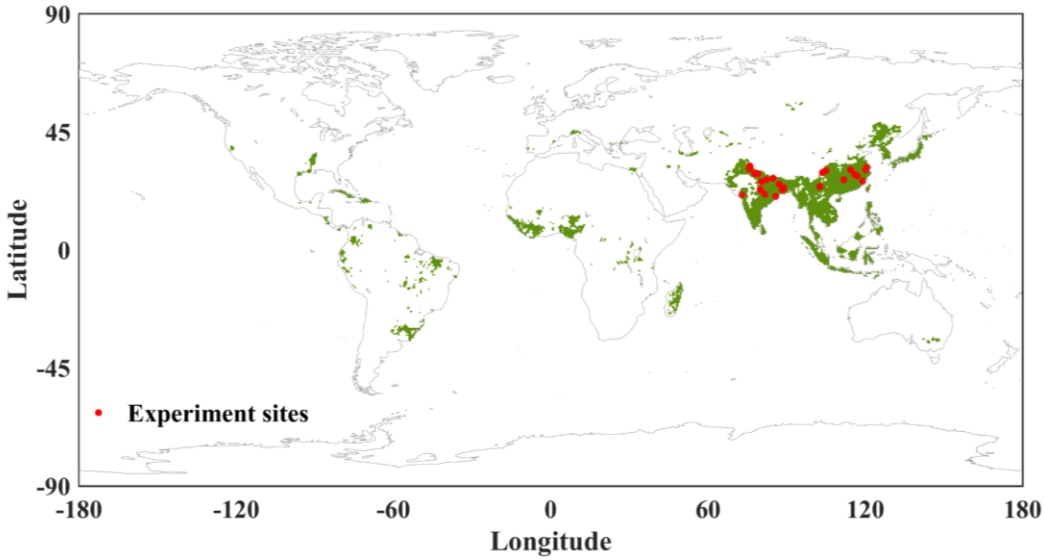
Supplementary Fig. 3: Rice yield losses due to extreme temperatures as affected by N addition. NPK, inorganic fertilizer; NPK+N, a combination of inorganic fertilizer and supplementary N addition. Error bars represent standard errors (*n*=5). In NPK + N treatment, additional inorganic N fertilizer at 36 kg N ha^{-1} was applied a week before temperature treatment. All other experimental conditions were identical to the pot experiment described in the main text.



Supplementary Fig. 4: Intensity of temperature extremes in areas of rice production during the current decade (2021-2030) and the last decade of this century (2091-2100). The original temperature data were extracted from four CMIP6 models (CanESM5, CNRM-CM6-1, INM-CM5-0, and HadGEM3-GC31-LL).



Supplementary Fig. 5: Method for calculating the intensity of extreme temperature using the 200th DOY (day of the year) at Nanchang site as an example. The multi-year temperatures for a day of the year were first extracted and detrended to remove the long-term trend in the temperature record. The temperatures beyond the range of [mean-SD, mean+SD] were then detected. The absolute difference between the temperature and the reasonable range was termed the intensity of a temperature extreme (solid yellow line). SD, standard deviation.



Supplementary Fig. 6: Locations of studies included in our meta-analysis. The global rice growing area is indicated in green.

Supplementary Table 1 Rice yields and the slopes and intercepts of linear regression between rice yield and intensity of temperature extremes affected by manure amendment and season in the field experiment. Means ± standard errors (n=3).

Rice crop	Treatment	Rice yield	Slope	Intercept
Early rice	NPK	5.65±0.12	-2.59±0.06	6.33±0.11
	NPKM	5.93±0.09	-2.09±0.30	6.14±0.04
Late rice	NPK	5.91±0.05	-4.80±0.20	6.85±0.09
	NPKM	6.34±0.05	-4.02±0.42	7.12±0.13
P				
	Manure	0.009	0.015	0.07
	Season	0.052	0.029	0.01
	Manure × Season	0.106	0.673	0.631

Supplementary Table 2 Correlation coefficients between climatic factors and rice yield in the field experiment.

Rice crop	Treatment	Mean temperature		Maximum temperature		Minimum Temperature	
		r	*P*	*r*	*P*	*r*	*P*
Early rice	NPK	0.133	0.44	0.197	0.127	0.033	0.851
	NPKM	0.105	0.55	0.257	0.466	0.056	0.755
Late rice	NPK	0.299	0.081	0.328	0.055	0.199	0.252
	NPKM	0.295	0.086	0.320	0.061	0.191	0.270

Supplementary Table 3 Effects of long-term manure amendment on the slope of the linear regression between rice yield and intensity of temperature extremes among the environmental factors.

Factor		Mean effect (%)	95% confidence interval (%)		*n*	*P*
			Lower	Upper		
Cropping system	Upland rice	-25.0	-35.9	-14.2	30	0.609
	Double rice	-29.4	-39.0	-20.2	15	
Manure type	Animal	-32.3	-42.2	-21.9	29	0.034
	Green	-14.6	-20.9	-7.8	16	
Soil texture	Heavy	-23.9	-30.6	-17.4	38	0.141
	Light	-39.0	-62.8	-6.4	7	
Soil organic carbon (g/kg)	<10	-25.4	-36.3	-14.9	26	0.768
	≥10	-28.0	-38.5	-17.0	19	
Manure N input rate (kg/ha)	<70	-21.1	-28.5	-13.1	31	0.045
	≥70	-37.1	-51.8	-22.2	14	
Ratio of manure N to total N input	<0.5	-16.1	-25.7	-3.7	14	0.100
	≥0.5	-30.8	-40.3	-21.3	31	
Inorganic fertilizers were replaced by manure	No	-35.4	-49.0	-21.7	16	0.072
	Yes	-21.0	-29.0	-12.7	29	

Lower % effects indicate lower yield sensitivity, i.e. smaller yield losses due to extreme temperatures (see supplementary Fig. 1)