Table S1 Abbreviations for variables.

Names of variables	Abbreviations	Names of variables	Abbreviations
Soil organic matter	SOC	Number seeds per pod	NSP
Soil total nitrogen	STN	Leaf chlorophyll content	LCC
Soil total phosphorus	STP	Node of the first flower	NFF
Soil available nitrogen	SAN	Single leaf area	SLA
Soil available phosphorus	SAP	Double pod rate	DPR
Soil available potassium	SAK	100 seeds weight	100-SW
Nitrate nitrogen	NN	Number pods per plant	NPP
Ammonium nitrogen	AN	Pod yield per plant	PYP
Alkaline hydrolyzable nitrogen	AHN	Pod chlorophyll content	PCC
Monthly average temperature	T	Total polyphenols content	TPC
Monthly average relative humidity	RH	Soluble protein content	SPC
Monthly average light intensity	LI	Starch content	SC
Monthly average UV intensity	UV	Soluble sugar content	SSC
Maximum monthly average temperature	MaxT	Fiber content	FC
Maximum monthly average relative humidity	MaxRH	Total sugar content	TSC
Maximum monthly average light intensity	MaxLI	Ascorbic acid content	AAC
Maximum monthly average UV intensity	MaxUV	The ratio of the thrips at first flowering stage	TQR1
Minimum monthly average temperature	MinT	The ratio of the thrips at second flowering stage	TQR2
Minimum monthly average relative humidity	MinRH	Thrips incidence at first flowering stage	TI1
Minimum monthly average light intensity	MinLI	The ratio of the thrips at second flowering stage	TI2
Minimum monthly average UV intensity	MinUV	Incidence of cercospora leaf spot disease	CLSI
Diurnal temperature variation	DTV	Severity of cercospora leaf spot disease	CLSS
Harvest period	HP	Incidence of powdery mildew disease	PMI
Pod weight	PW	Severity of powdery mildew disease	PMS
Pod length	PL	Incidence of rust disease	RI
Pod breadth	PB	Severity of rust disease	RS
Pod thickness	PT		

Table S2 Primary phenological growth stages and growing degree days (GDD) for yard-long beans under different cultivation conditions.

Cultivation conditions	Date of sowing	Date of first flowering	Date of first harvest	GDD of first flowering (℃·days)	GDD of first harvest (℃·days)
OF	9-18	10-7	10-20	528.8	688.9
SSP	9-18	10-9	10-23	604.2	784.4
IPN	9-18	10-10	10-23	622.7	807.1
FSP	9-18	10-10	10-23	631.3	802.9

Growing degree days (℃·days) were calculated following the method (Bondade and Deshpande, 2021)

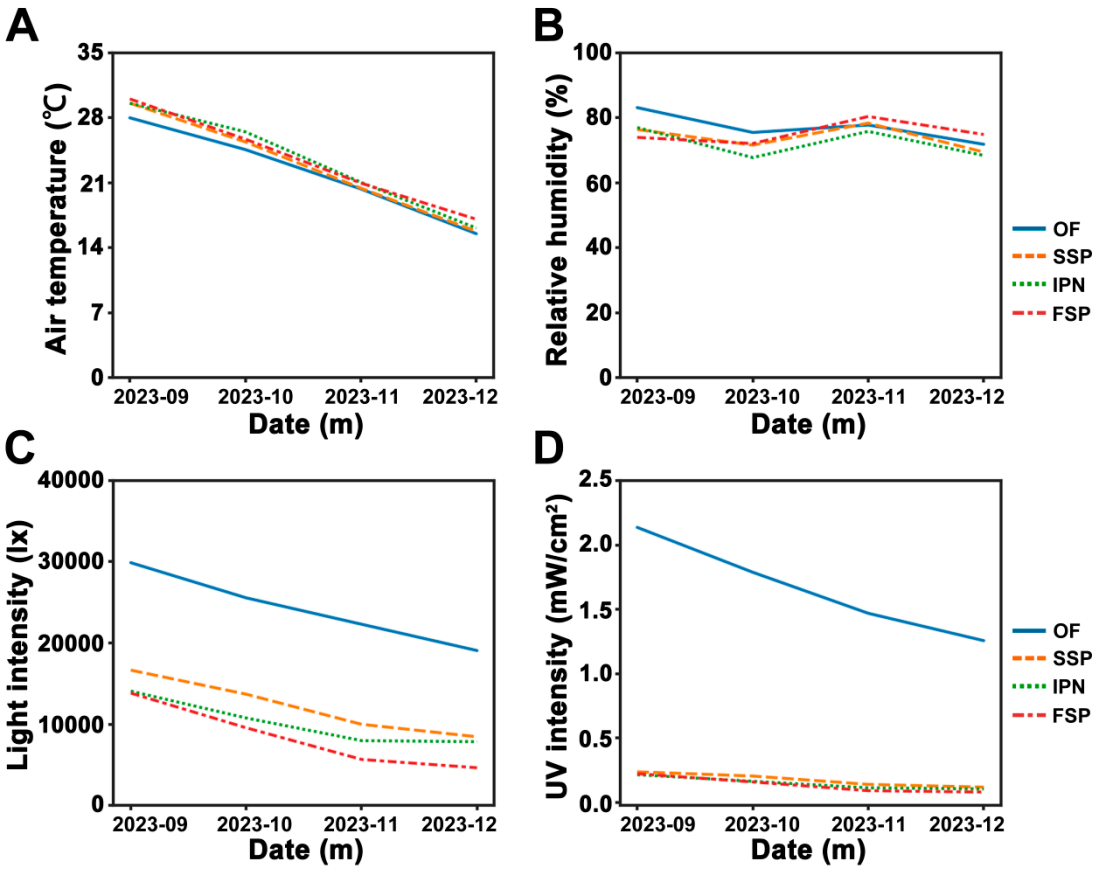


Figure S1 Monthly average line chart of temperature (A), relative humidity(B), light intensity (C), and UV intensity (D). OF (open field); SSP (single-span polyhouse); IPN (insect-proof net house); FSP (five-span polyhouse).

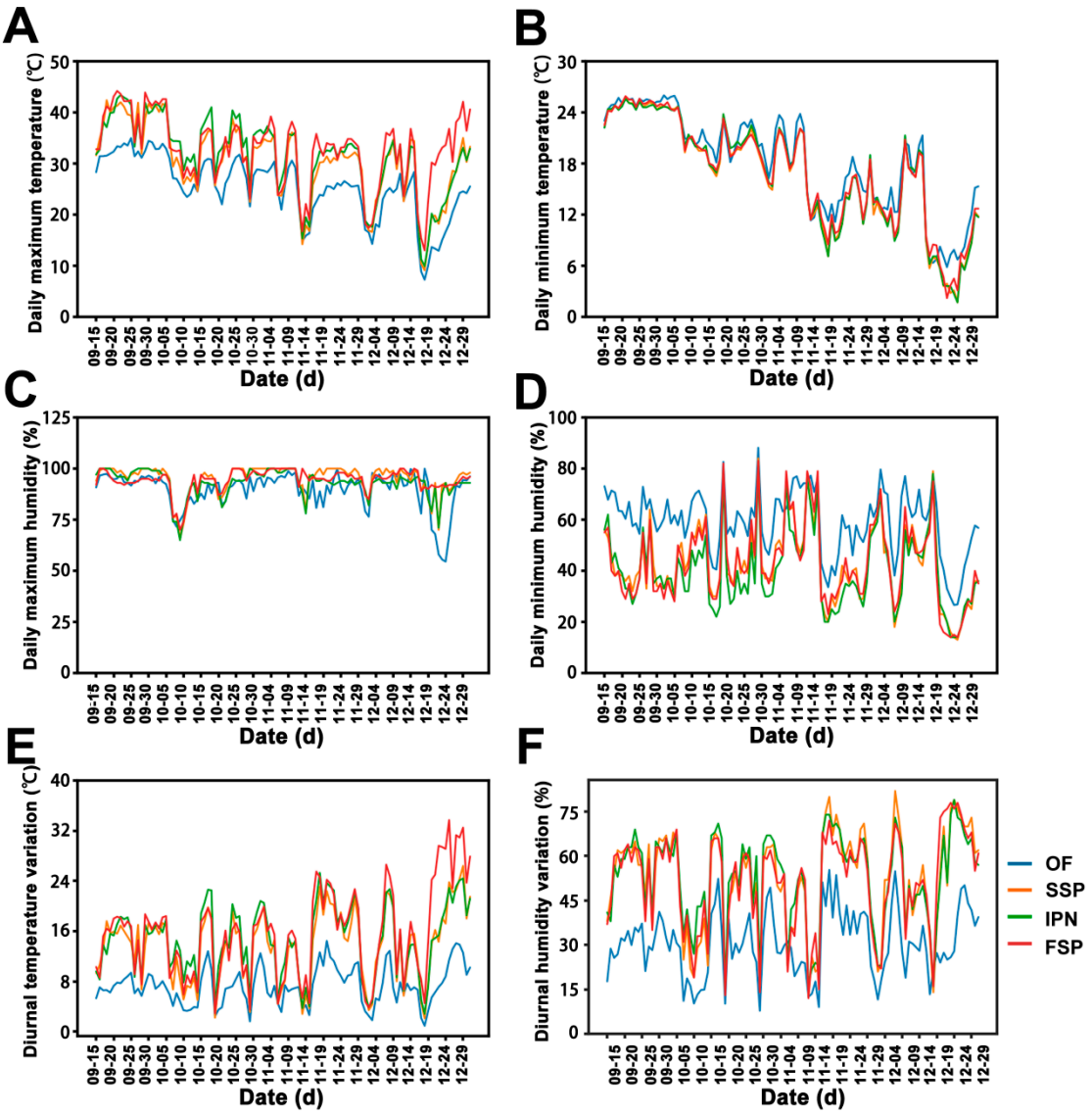


Figure S2 Daily maximum and minimum temperature (A-B), daily maximum and minimum humidity (C-D), and diurnal variation of temperature and relative humidity under different cultivation conditions (E-F). The dates go from September 15, 2023 to December 31, 2023. OF (open field); SSP (single-span polyhouse); IPN (insect-proof net house); FSP (five-span polyhouse).

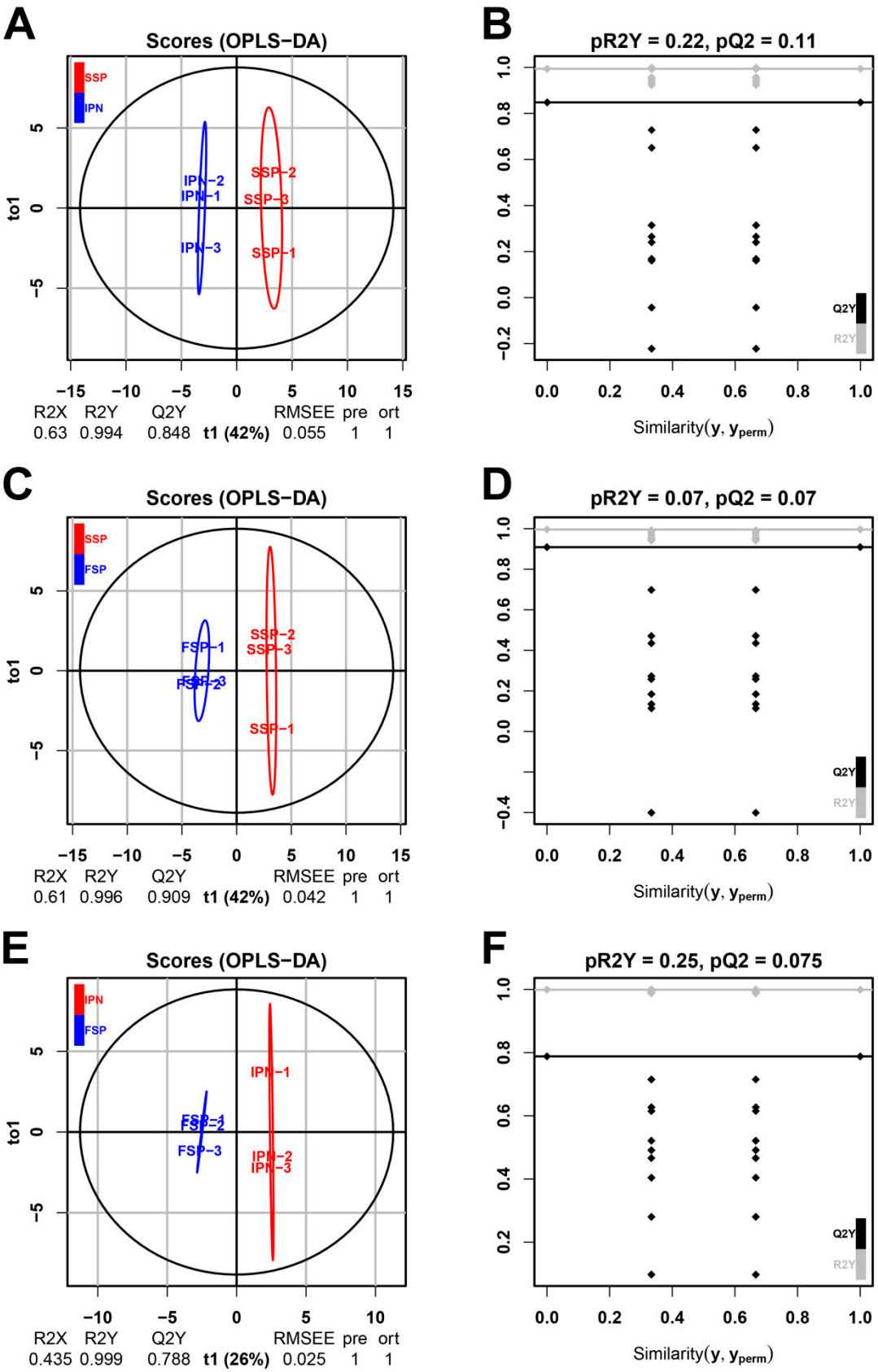


Figure S3 Orthogonal partial least squares discriminant analysis (OPLS-DA) scores and permutation testing of the all evaluation parameters from various protected cultivation groups. (A, B) SSP vs. IPN. (C, D) SSP vs. FSP. (E, F) IPN vs. FSP.

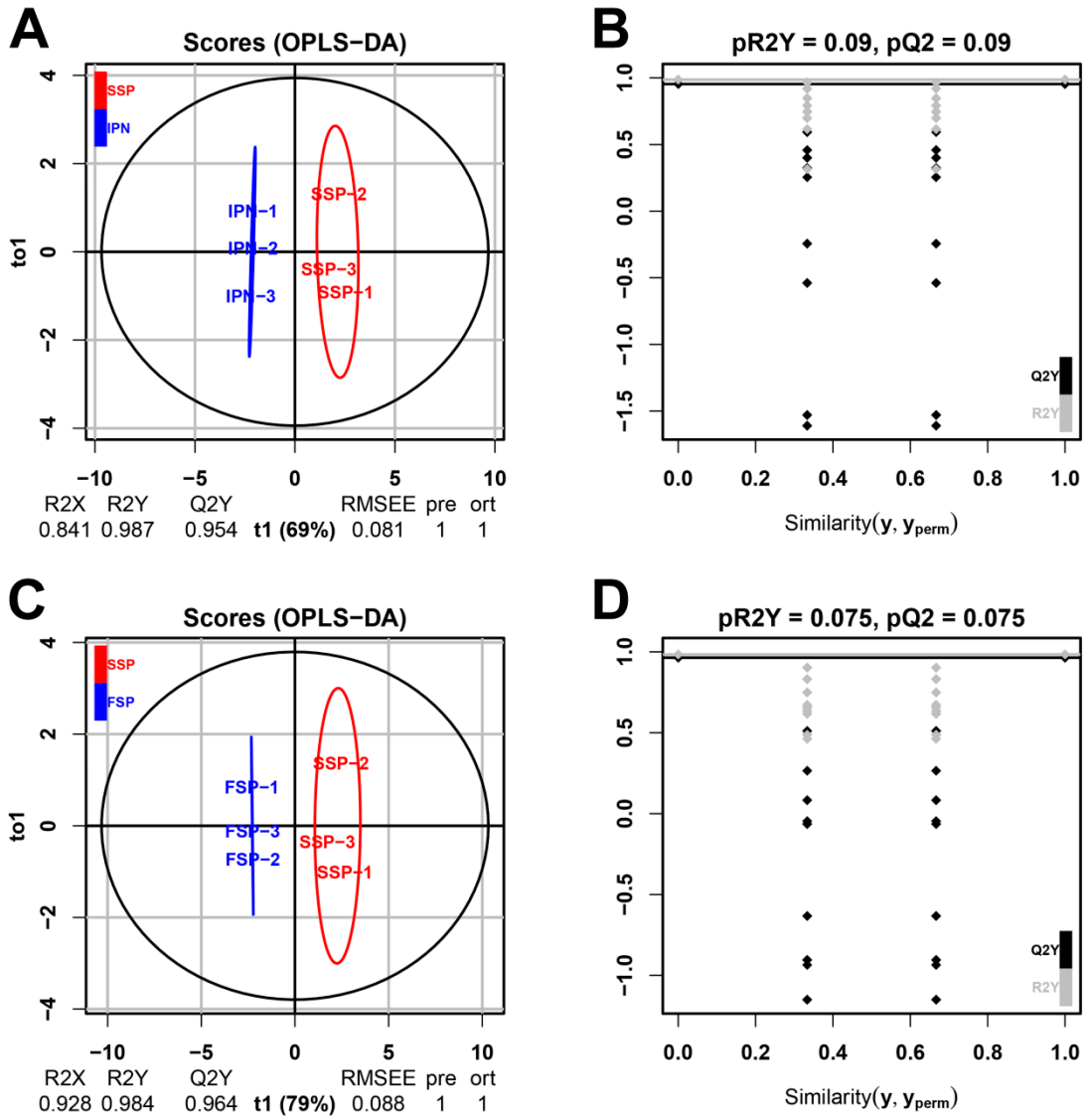


Figure S4 Orthogonal partial least squares discriminant analysis (OPLS-DA) scores and permutation testing of the quality evaluation parameters from various protected cultivation groups. (A, B) SSP vs. IPN. (C, D) SSP vs. FSP.

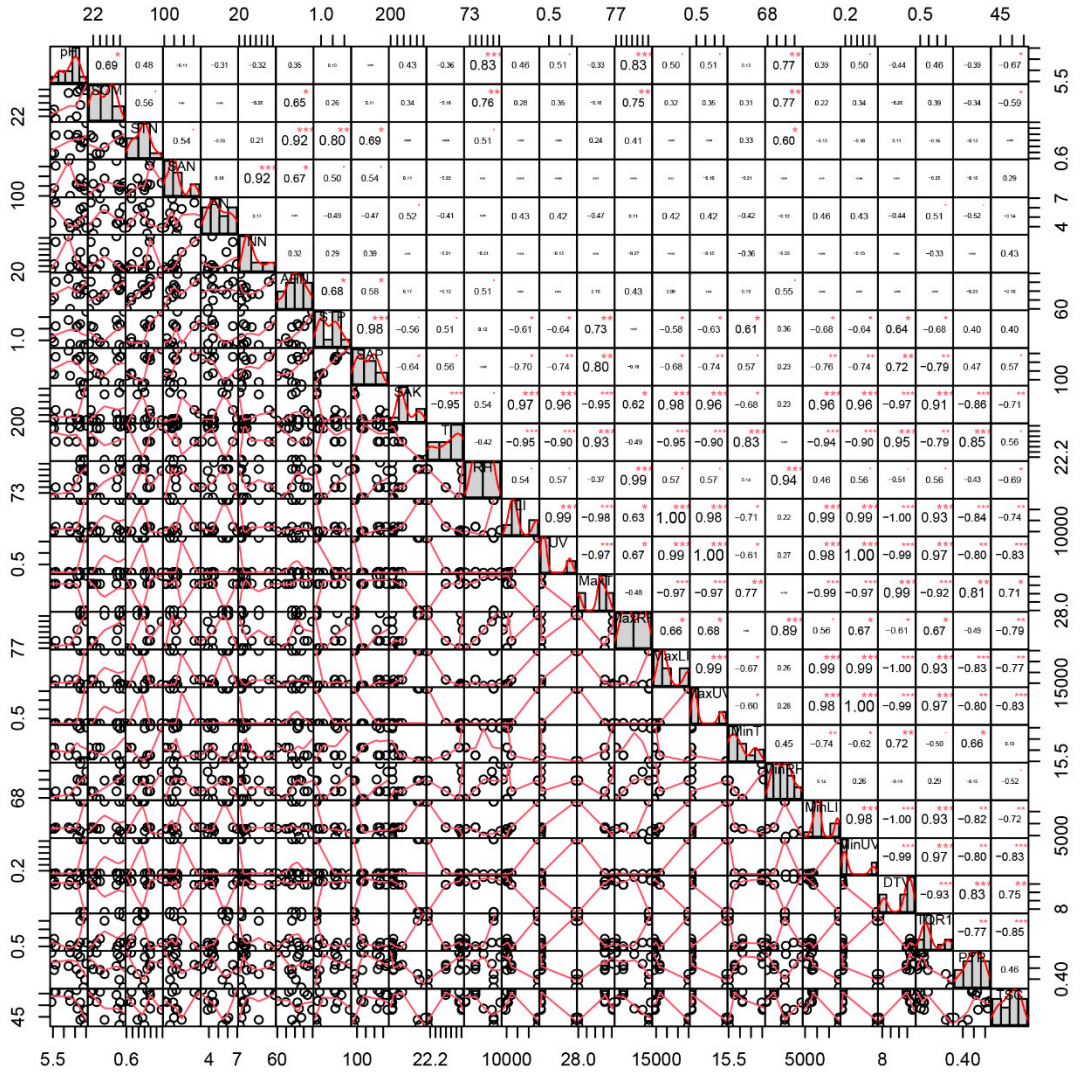


Figure S5 Pairwise comparison of dependent variables and explanatory variables. The panel in the upper right corner includes predicted pairwise Pearson's correlations. Abbreviations are shown in Table S1. *p < 0.05, **p < 0.01, ***p < 0.001.

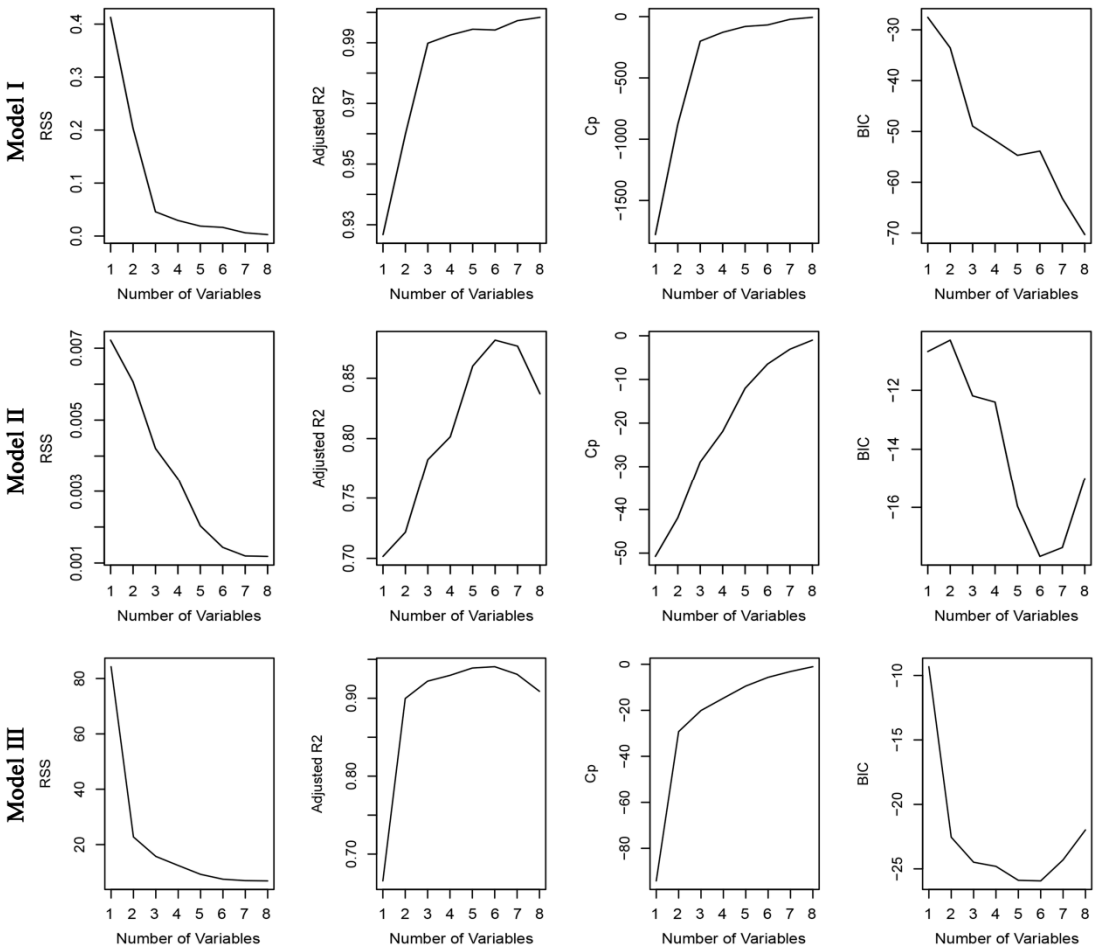


Figure S6 Plots of the residual sum of squares (RSS), the adjusted R^2, Mallows's Cp (Cp), and the Bayesian information criterion (BIC) of full subset regression models.

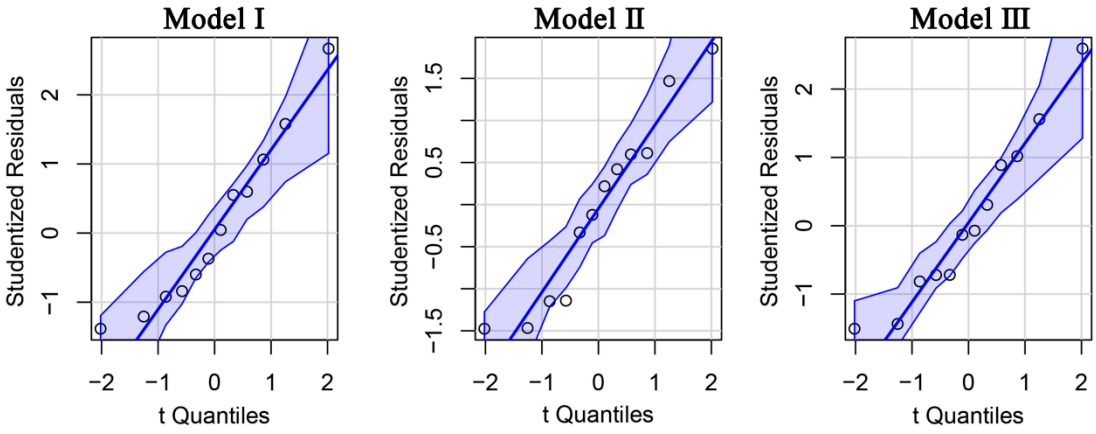


Figure S7 Normal quantile-quantile plots (QQ-plots) of studentized residuals of multivariate linear regression. The diagonal solid blue lines correspond to the normal distribution. The blue shaded areas (envelope) represent 95% confidence intervals.

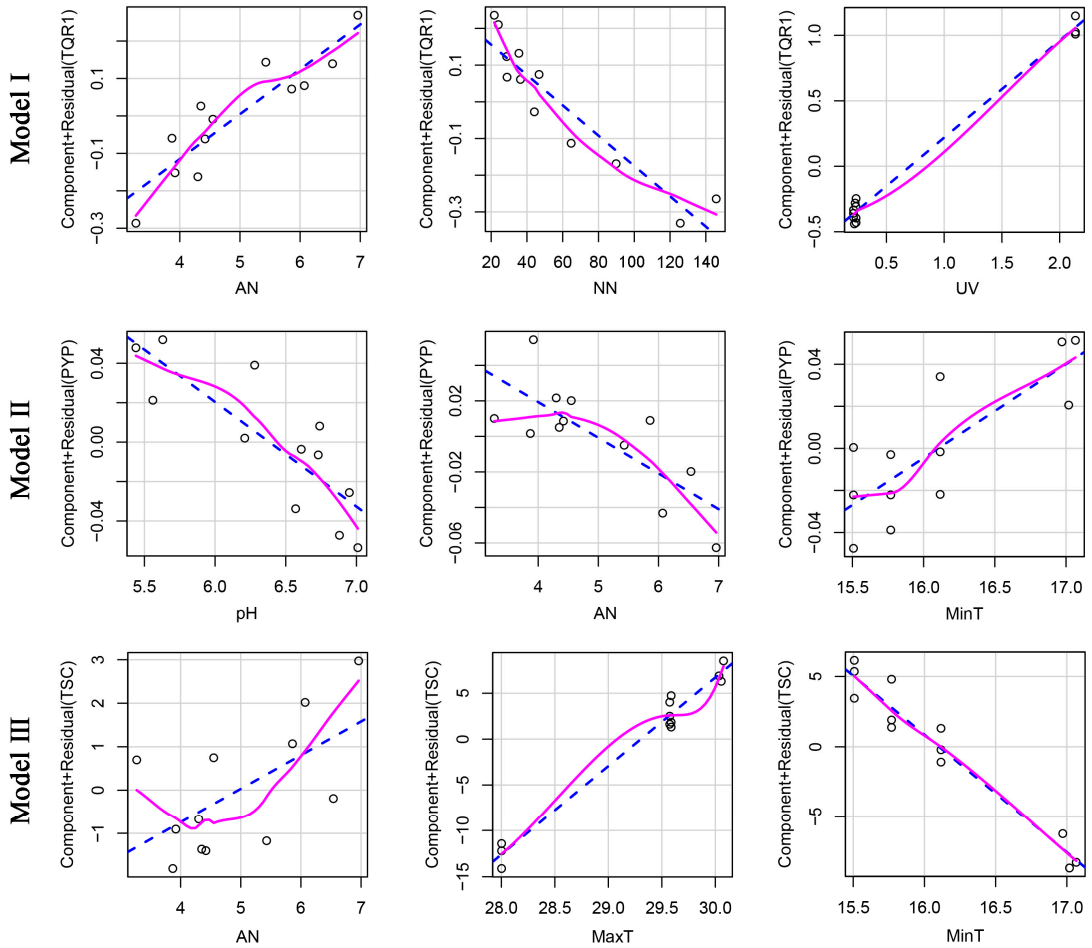


Figure S8 Partial residual plots for the multivariate regression of TQR1, PYP, and TSC for various ecological factors.

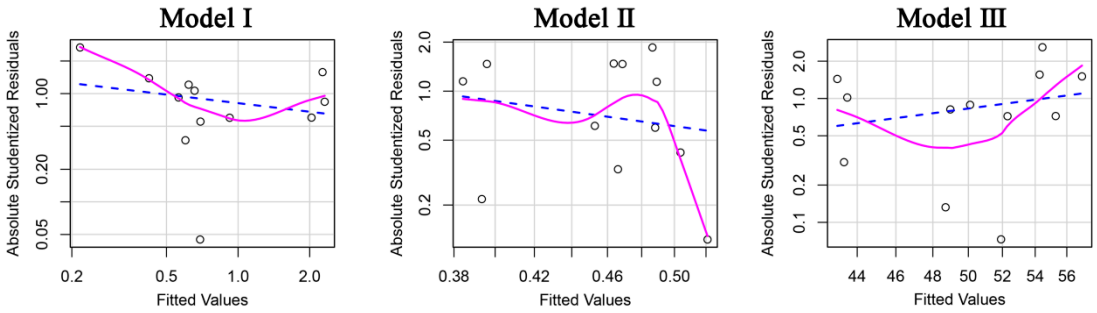


Figure S9 Residual distribution plot for assessing homoscedasticity.

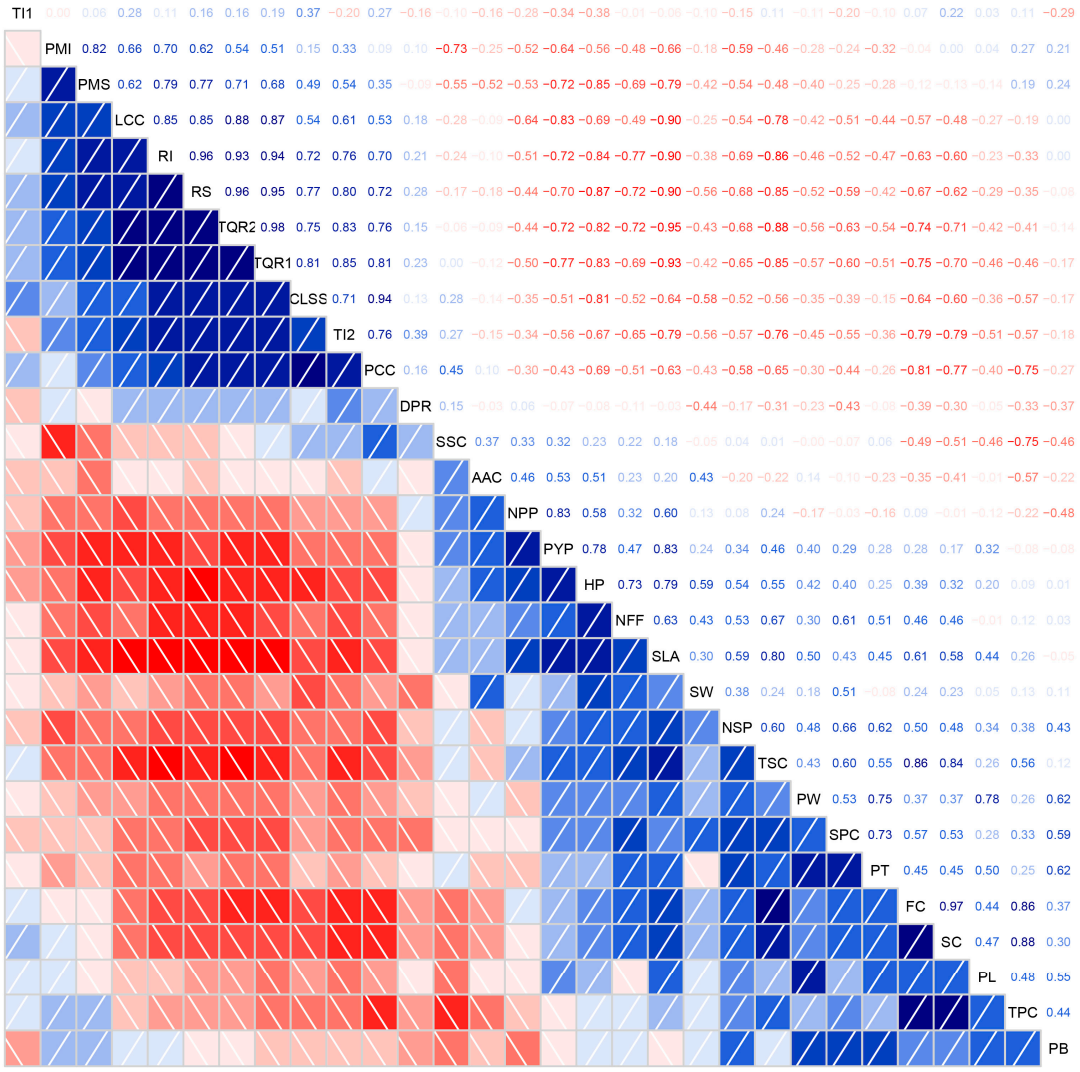


Figure S10 Correlation analysis among 30 performance variables. Abbreviations are shown in Table S1.