Appendix

Supplementary Figures and Tables

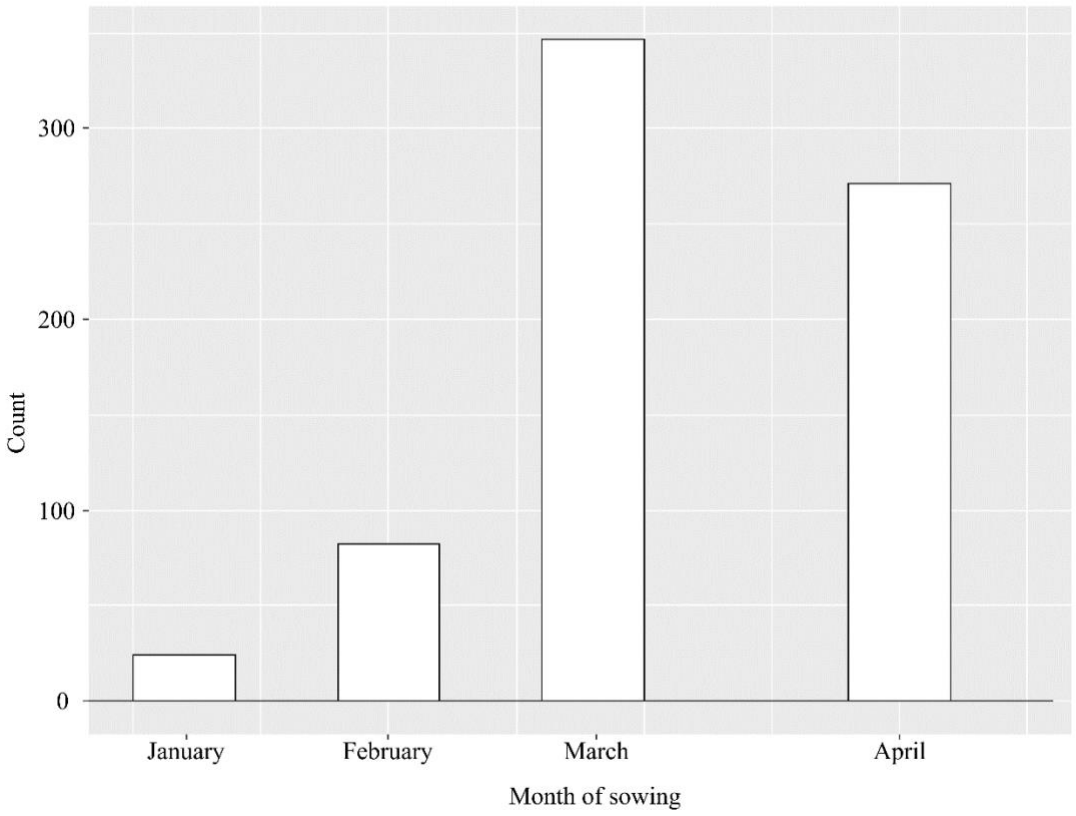

Figure S1. *Distribution of sowing events per month observed in the study area. Data from 2017 to 2020.*

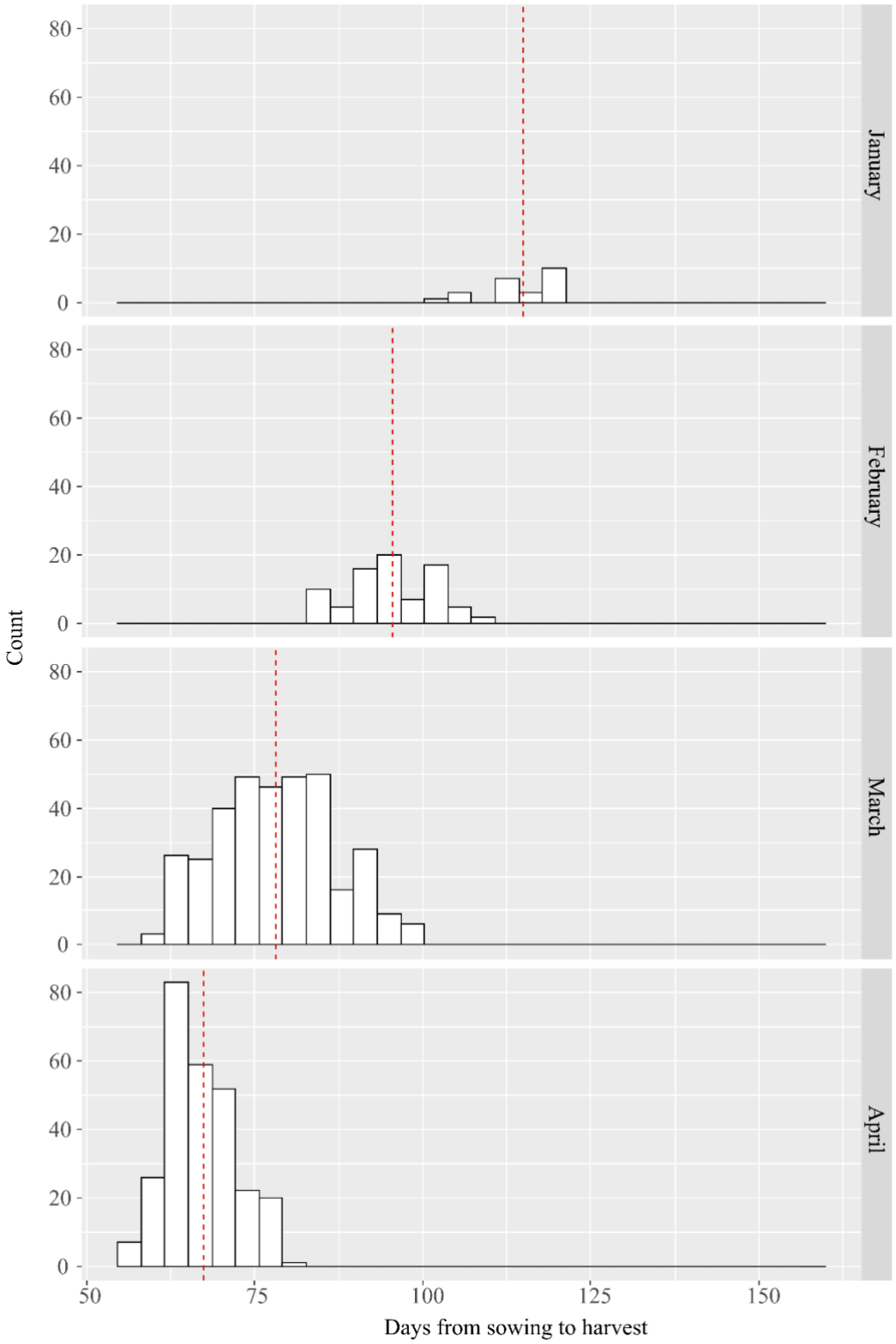

***Figure S2**. Distribution of crop cycle duration for different sowing time observed in the study area. Data from 2017 to 2020. The dotted red line is the mean value.*

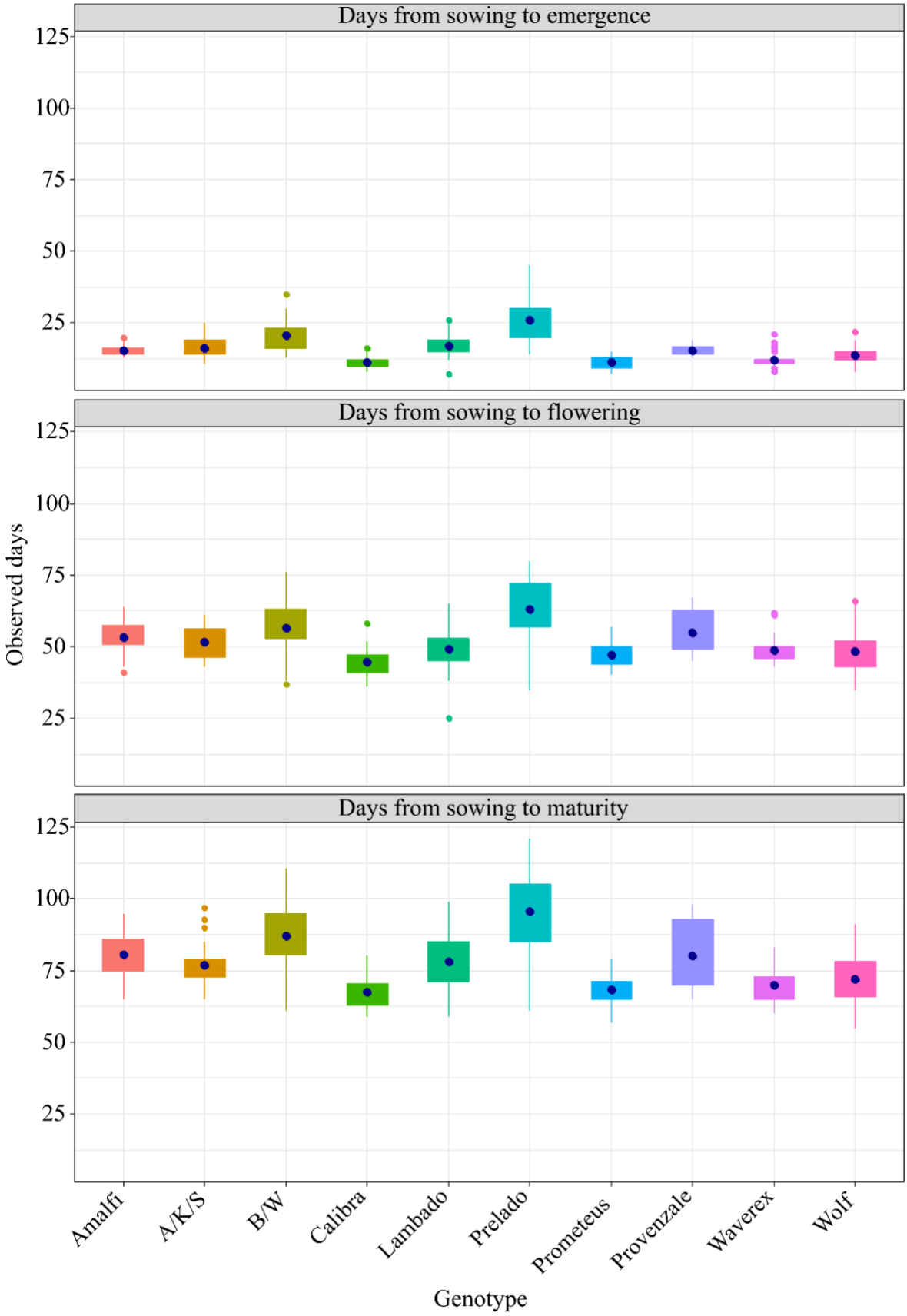

Figure S3. *Variability in observed days to emergence, days to flowering, and days to maturity for each of the thirteen pea varieties.*

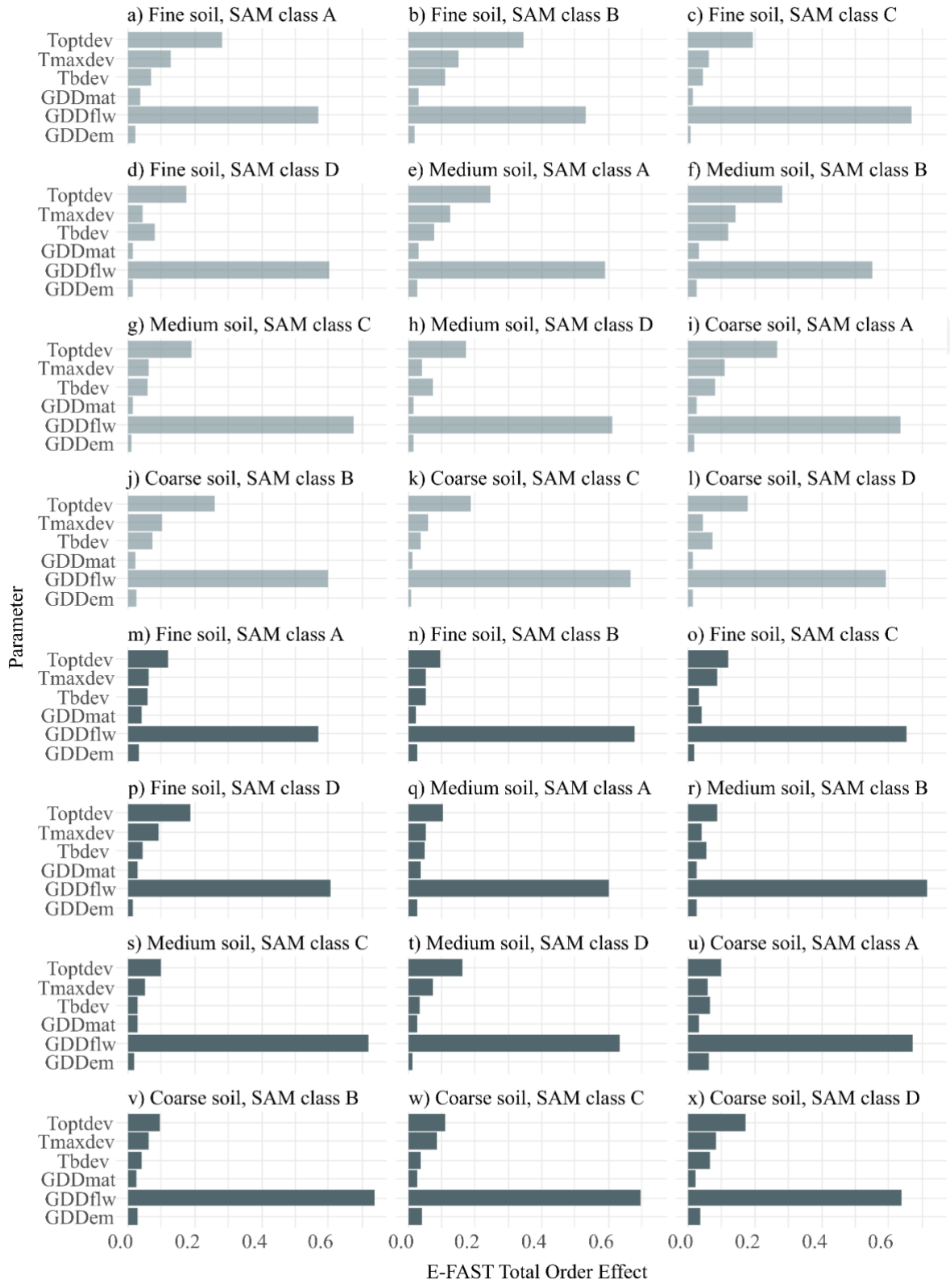

Figure S4. *Sensitivity index (E-FAST Total Order Effect) for each of the 24 agro-climatic contexts considered (i.e., combination of sowing time, soil and climate conditions). Panels a-l: early sowing; panels m-x: late sowing. Response variable:* Y_{index}*. See Table S4 for parameter description. SAM: Synthetic AgroMeteorological indicator (class A: SAM≤-0.35; class B: -0.35<SAM≤-0.25; class C: -0.25<SAM≤-0.15; class D: SAM>-0.15).*

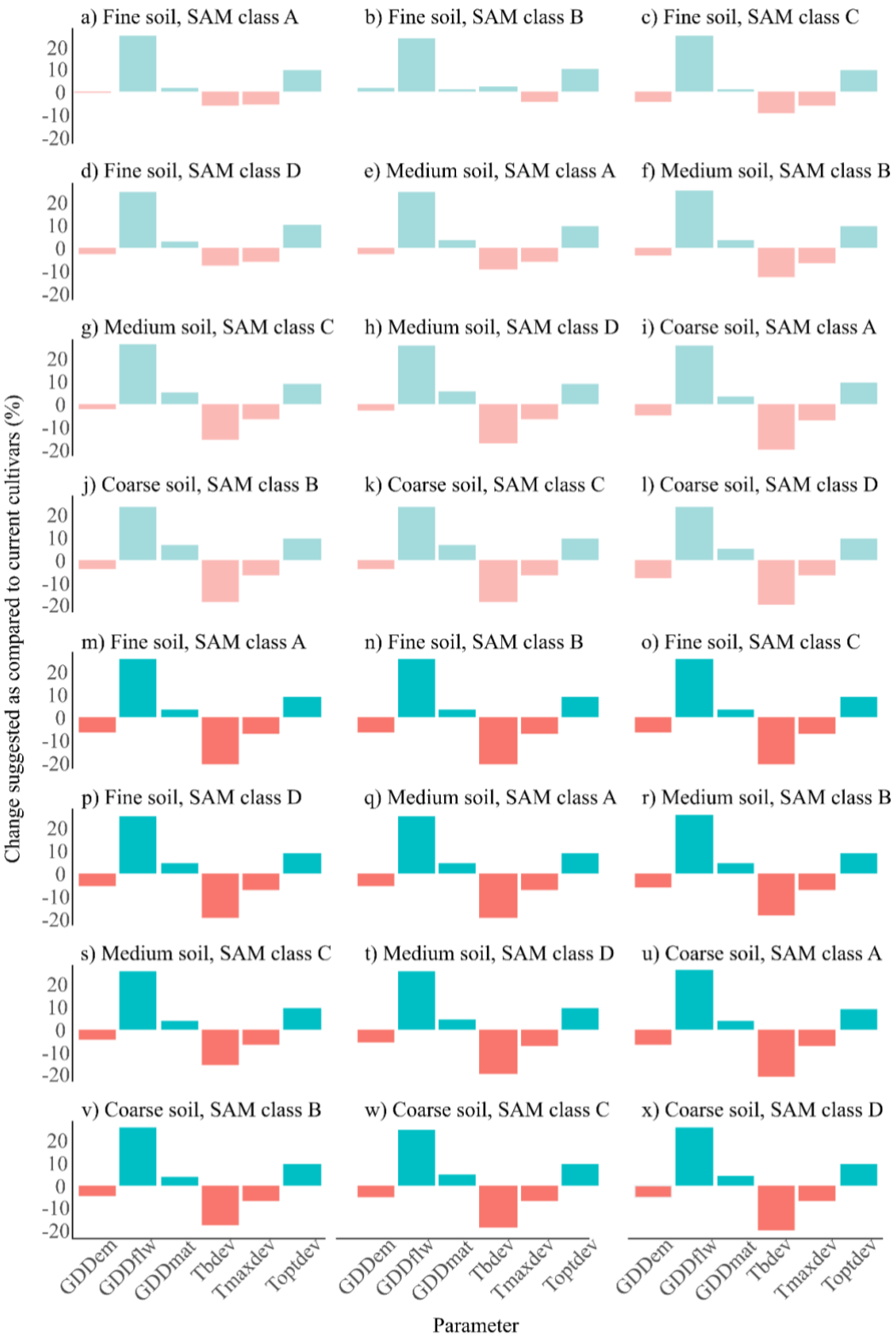

Figure S5. *Ideotypes designed to improve yield and yield stability under each of the 24 agro-climatic contexts (i.e., combination of sowing time, soil and climate conditions). Panels with light bars (a-l): early sowing; panels with dark bars (m-x): late sowing. See Table S4 for parameter description. SAM: Synthetic AgroMeteorological indicator (class A: SAM≤-0.35; class B: -0.35<SAM≤-0.25; class C: -0.25<SAM≤-0.15; class D: SAM>-0.15).*

Table S1. *Field experiments used for calibrating the crop model WOFOST-GT2 for field pea.*

Activity	Location	Coordinates	Soil texture classification (USDA)	Sowing date	Cultivar
Calibration	San Pietro in Trento	44.32° N, 12.08° E	sandy-loam	15 April 2016	Wolf
	San Rocco al Porto	45.08° N, 9.69° E	silt loam	16 April 2016	Wolf
	San Rocco al Porto	45.08° N, 9.69° E	silt loam	23 March 2017	Wolf
	Bagnolo	44.93° N, 9.94° E	clay	15 March 2017	Wolf
Validation	San Pietro in Trento	44.32° N, 12.08° E	sandy clay	13 April 2016	Waverex
	Jolanda di Savoia	44.88° N, 11.98° E	clay	2 April 2016	Wolf
	Alseno	44.92° N, 9.96° E	clay	13 March 2017	Wolf

Table S2*. Pea varieties considered and number of observations available for each. Varieties with few observations were grouped together (Agami, Keysee and Starlight; Boston and Wav1337).*

Variety	Group	Number of observations		
		Emergence	Flowering	Maturity
Amalfi		34	34	34
Calibra		35	33	44
Lambado		123	105	142
Prelado		92	82	114
Prometeus		48	45	65
Provenzale		30	30	30
Waverex		67	66	90
Wolf		152	146	164
Agami Keysee Starlight	A/K/S	40	34	53
Boston Wav1337	B/W	62	62	68

Table S3. *Model calibration and validation. MAE: mean absolute error; RRMSE: relative root mean square error; EF: modelling efficiency; CRM: coefficient of residual mass; R^2: coefficient of determination of the regression between measured and simulated values.*

Activity	Variable	MAE	RRMSE	EF	CRM	R^2
Calibration	Leaf area index (-)	0.50	28.88	0.88	0.13	0.99
	Aboveground biomass [a] (t ha^{-1})	1.02	42.08	0.78	-0.1	0.81
	Leaf biomass [a] (t ha^{-1})	0.28	39.16	0.56	-0.09	0.63
	Stem biomass [a] (t ha^{-1})	0.46	48.94	0.59	-0.10	0.62
	Pod biomass [a] (t ha^{-1})	0.54	43.51	0.86	-0.02	0.88
Validation	Aboveground biomass [a] (t ha^{-1})	0.84	27.01	0.85	-0.17	0.91
	Leaf biomass [a] (t ha^{-1})	0.29	37.61	0.53	-0.16	0.63
	Stem biomass [a] (t ha^{-1})	0.53	42.59	0.52	-0.19	0.67
	Pod biomass [a] (t ha^{-1})	0.59	41.31	0.86	-0.07	0.87

[a] *Dry biomass.*

Table S4. *Trait distribution and related parameters. W statistics and p-value of the Shapiro-Wilk normality test are also reported.*

Trait	Distribution	Distribution's parameters	W statistics	*p*-value
Growing degree days from sowing to emergence (GDDem; °C-days)	Normal	mean 124.5, standard dev. 21.1	0.882	0.14
Growing degree from emergence to flowering (GDDflw; °C-days)	Normal	mean 450.2, standard dev. 102.6	0.935	0.50
Growing degree days from flowering to maturity (GDDmat; °C-days)	Normal	mean 412.2, standard dev. 45.4	0.977	0.95
Base temperature for development (Tbase; °C)	Normal	mean 4, standard dev. 0.9	0.903	0.24
Optimum temperature for development (Topt; °C)	Normal	mean 24.3, standard dev. 2.3	0.875	0.11
Maximum temperature for development (Tmax; °C)	Normal	mean 33.6, standard dev. 2.3	0.948	0.65