Understanding photothermal interactions can help expand production range and increase genetic diversity of lentil (*Lens culinaris* Medik.)

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Contents

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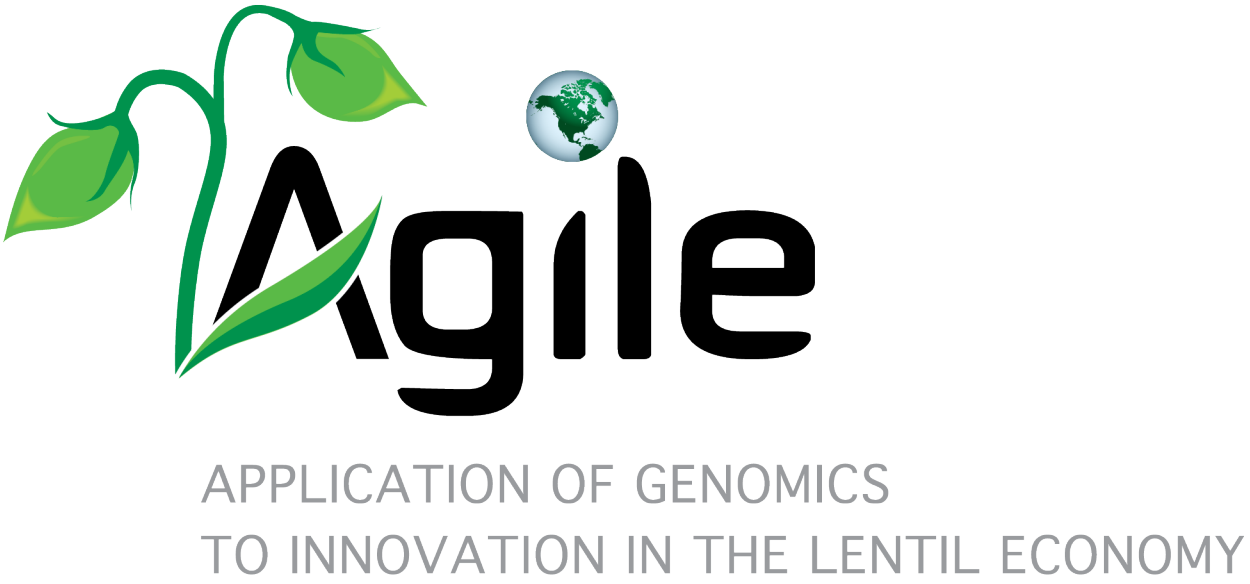
View as pdf

Source Code Vignette (Phenology_Vignette.html)

Data

Contents

AGILE Project



Collaborators

- Department of Plant Sciences and Crop Development Centre, University of Saskatchewan, Saskatoon, Saskatchewan, Canada
- United States Department of Agriculture Western Region Plant Introduction Station, Pullman, Washington, USA
- International Center for Agriculture Research in the Dry Areas, Rabat, Morocco
- Institute for Sustainable Agriculture, Spanish National Research Council, Cordoba, Spain
- School of Agriculture, Forestry, Food and Environmental Sciences, University of Basilicata, Potenza, Italy
- International Center for Agriculture Research in the Dry Areas, New Delhi, India
- Local Initiatives for Biodiversity, Research and Development, Pokhara, Nepal
- Bangladesh Agricultural Research Institute, Jessore, Bangladesh

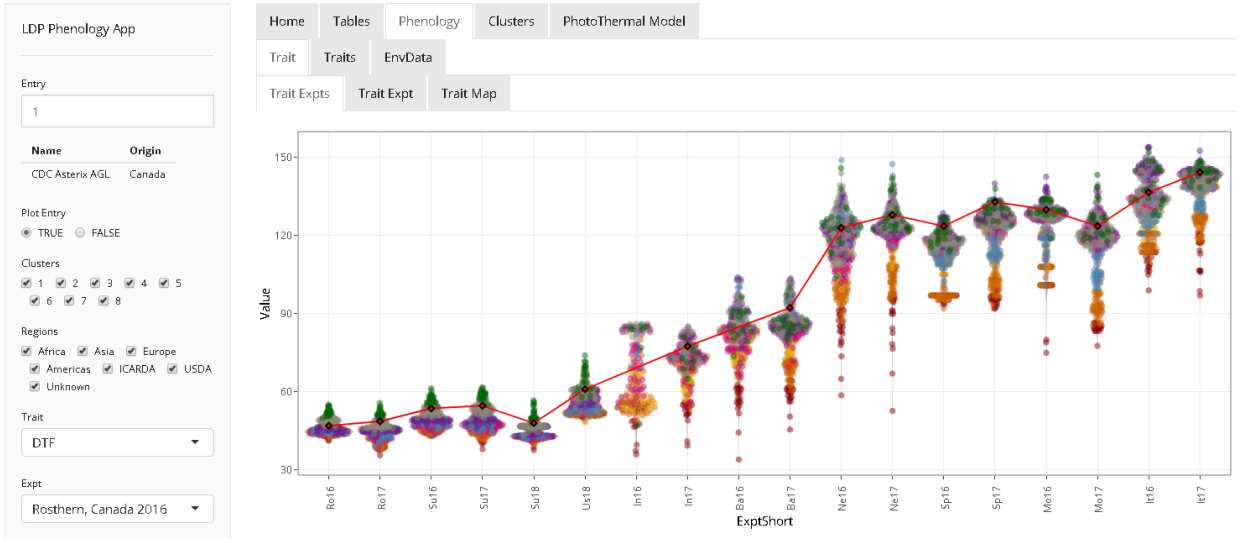
Sponsors

- Saskatchewan Pulse Growers Association
- Western Grains Research Foundation
- GenomePrairie
- GenomeCanada
- Saskatchewan Ministry of Agriculture

Shiny App

Download this repository and run `app.R` in `R`

or visit https://derek-wright-usask.shinyapps.io/AGILE_LDP_Phenology/



Figures

Figure 1

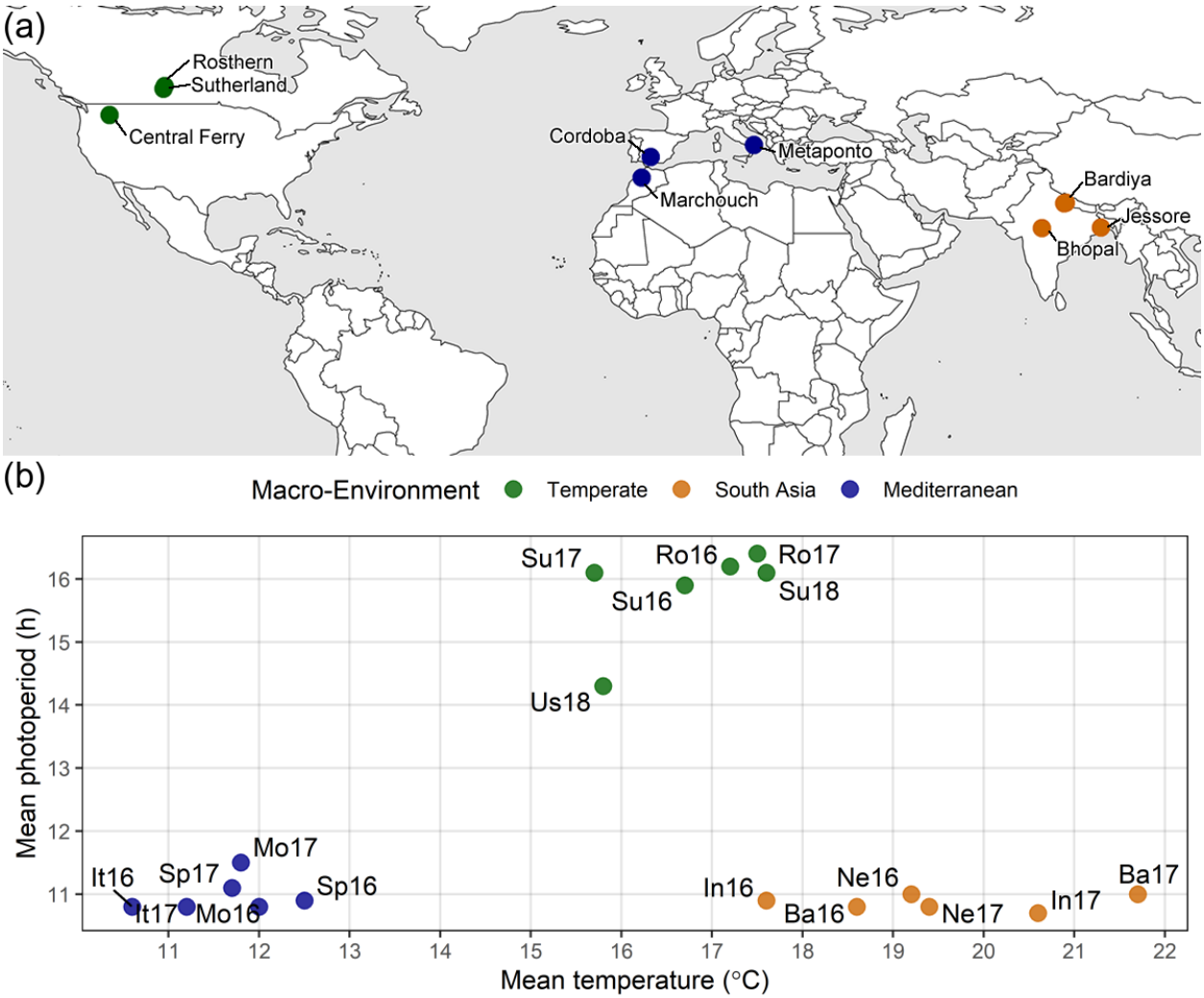


Figure 1: Growing Environments. (a) Locations of field trials conducted in the summer and winter of 2016, 2017 and 2018, along with (b) mean temperature and photoperiod of each field trial: Rosthern, Canada 2016 and 2017 (Ro16, Ro17), Sutherland, Canada 2016, 2017 and 2018 (Su16, Su17, Su18), Central Ferry, USA 2018 (Us18), Metaponto, Italy 2016 and 2017 (It16, It17), Marchouch, Morocco 2016 and 2017 (Mo16, Mo17), Cordoba, Spain 2016 and 2017 (Sp16, Sp17), Bhopal, India 2016 and 2017 (In16, In17), Jessore, Bangladesh 2016 and 2017 (Ba16, Ba17), Bardiya, Nepal 2016 and 2017 (Ne16, Ne17).

Figure 2

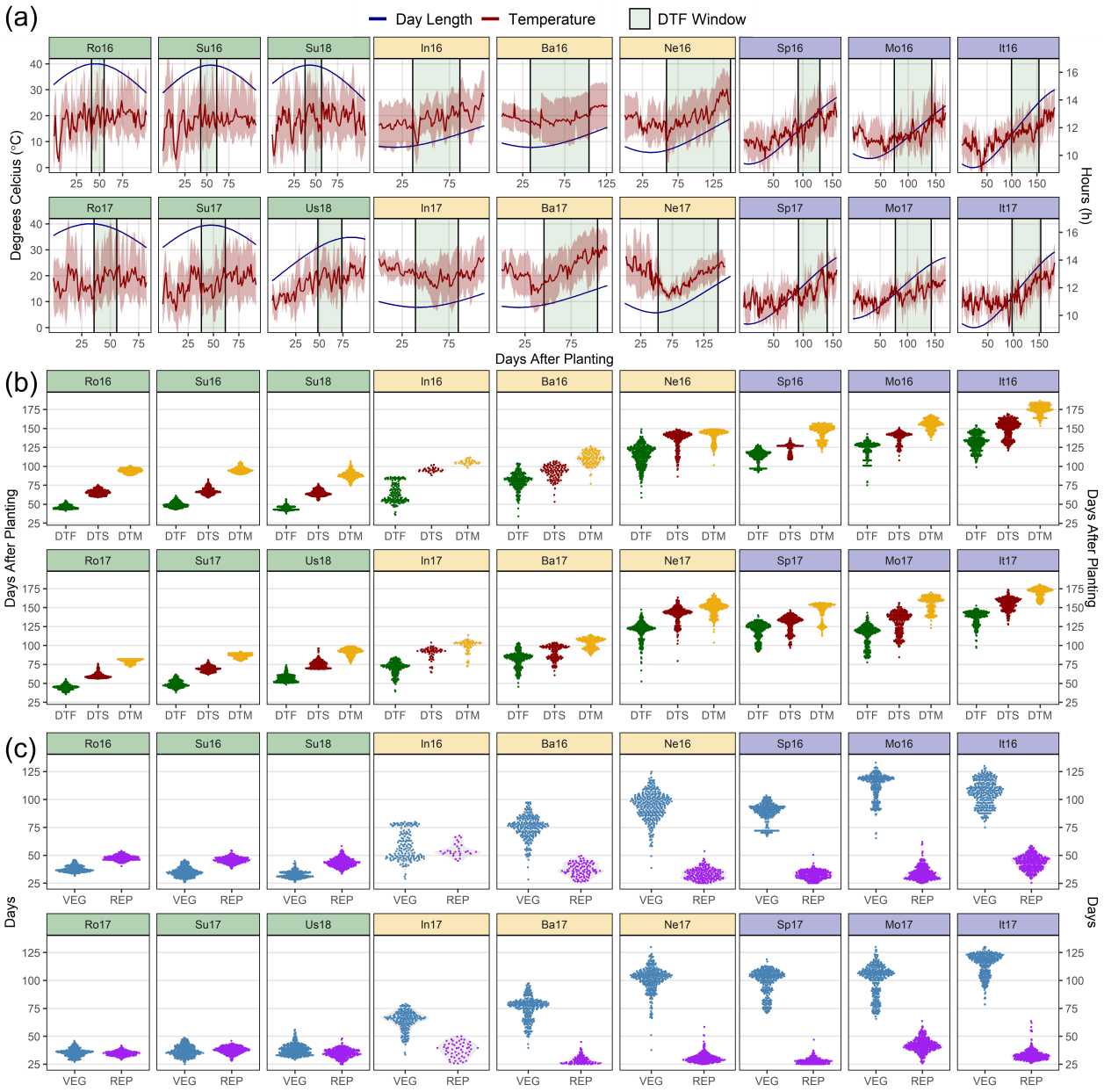


Figure 2: Variations in temperature, day length and phenological traits across contrasting environment for a lentil (Lens culinaris Medik.) diversity panel. (a) Daily mean temperature (red line) and day length (blue line) from seeding to full maturity of all genotypes. The shaded ribbon represents the daily minimum and maximum temperature. The shaded area between the vertical bars corresponds to the windows of flowering. (b) Distribution of mean days from sowing to: flowering (DTF), swollen pods (DTS) and maturity (DTM), and (c) vegetative (VEG) and reproductive periods (REP) of 324 genotypes across 18 site-years. Rosthern, Canada 2016 and 2017 (Ro16, Ro17), Sutherland, Canada 2016, 2017 and 2018 (Su16, Su17, Su18), Central Ferry, USA 2018 (Us18), Metaponto, Italy 2016 and 2017 (It16, It17), Marchouch, Morocco 2016 and 2017 (Mo16, Mo17), Cordoba, Spain 2016 and 2017 (Sp16, Sp17), Bhopal, India 2016 and 2017 (In16, In17), Jessore, Bangladesh 2016 and 2017 (Ba16, Ba17), Bardiya, Nepal 2016 and 2017 (Ne16, Ne17).

Figure 3

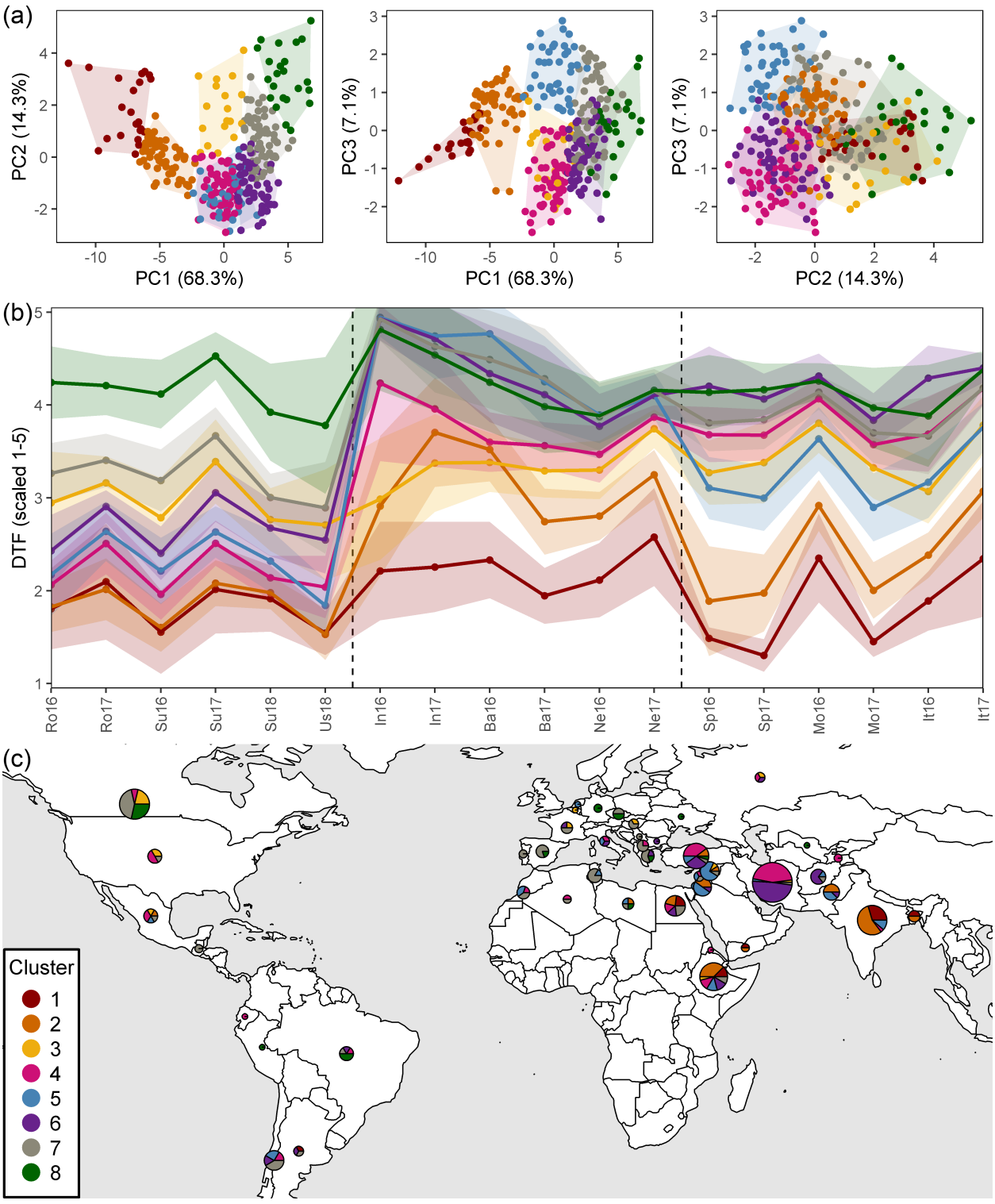

(a)
PC2 (14.3%)
PC1 (68.3%)
PC3 (7.1%)
PC1 (68.3%)
PC3 (7.1%)
PC2 (14.3%)
(b)
DTF (scaled 1-5)
Ro16
Ro17
Su16
Su17
Su18
Us18
In16
In17
Ba16
Ba17
Ne16
Ne17
Sp16
Sp17
Mo16
Mo17
It16
It17
(c)
Cluster
1
2
3
4
5
6
7
8

Figure 3: Clustering of a lentil (Lens culinaris Medik.) diversity panel based days from sowing to flower (DTF). (a) Principal Component Analysis on DTF, scaled from 1-5, and hierarchical k-means clustering into eight groups. (b) Mean scaled DTF (1-5) for each cluster group across all field trials: Rosthern, Canada 2016 and 2017 (Ro16, Ro17), Sutherland, Canada 2016, 2017 and 2018 (Su16, Su17, Su18), Central Ferry, USA 2018 (Us18), Metaponto, Italy 2016 and 2017 (It16, It17), Marchouch, Morocco 2016 and 2017 (Mo16, Mo17), Cordoba, Spain 2016 and 2017 (Sp16, Sp17), Bhopal, India 2016 and 2017 (In16, In17), Jessore, Bangladesh 2016 and 2017 (Ba16, Ba17), Bardiya, Nepal 2016 and 2017 (Ne16, Ne17). Shaded areas represent one standard deviation from the mean. Dashed, vertical bars separate temperate, South Asian and Mediterranean macro-environments. (c) Composition of cluster groups in genotypes by country of origin. Pie size is relative to the number of genotypes originating from that country.

Figure 4

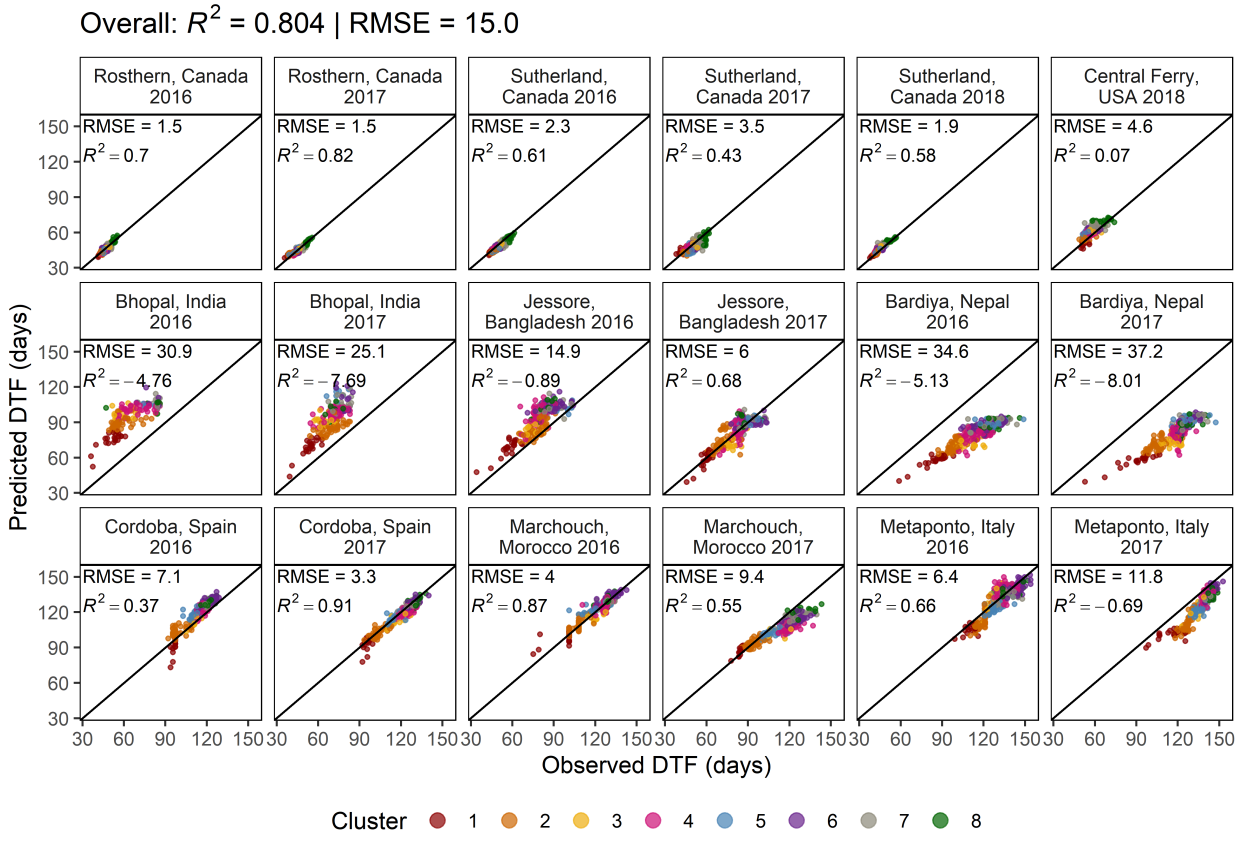


Figure 4: Comparison of observed and predicted values for days from sowing to flowering (DTF) for a lentil (Lens culinaris Medik.) diversity panel calculated using equation 1. For each site-year, the model was retrained after removing all observations from that location, regardless of year before predicting results from that location. R2 = coefficient of determination, RMSE = root-mean-square error.

Figure 5

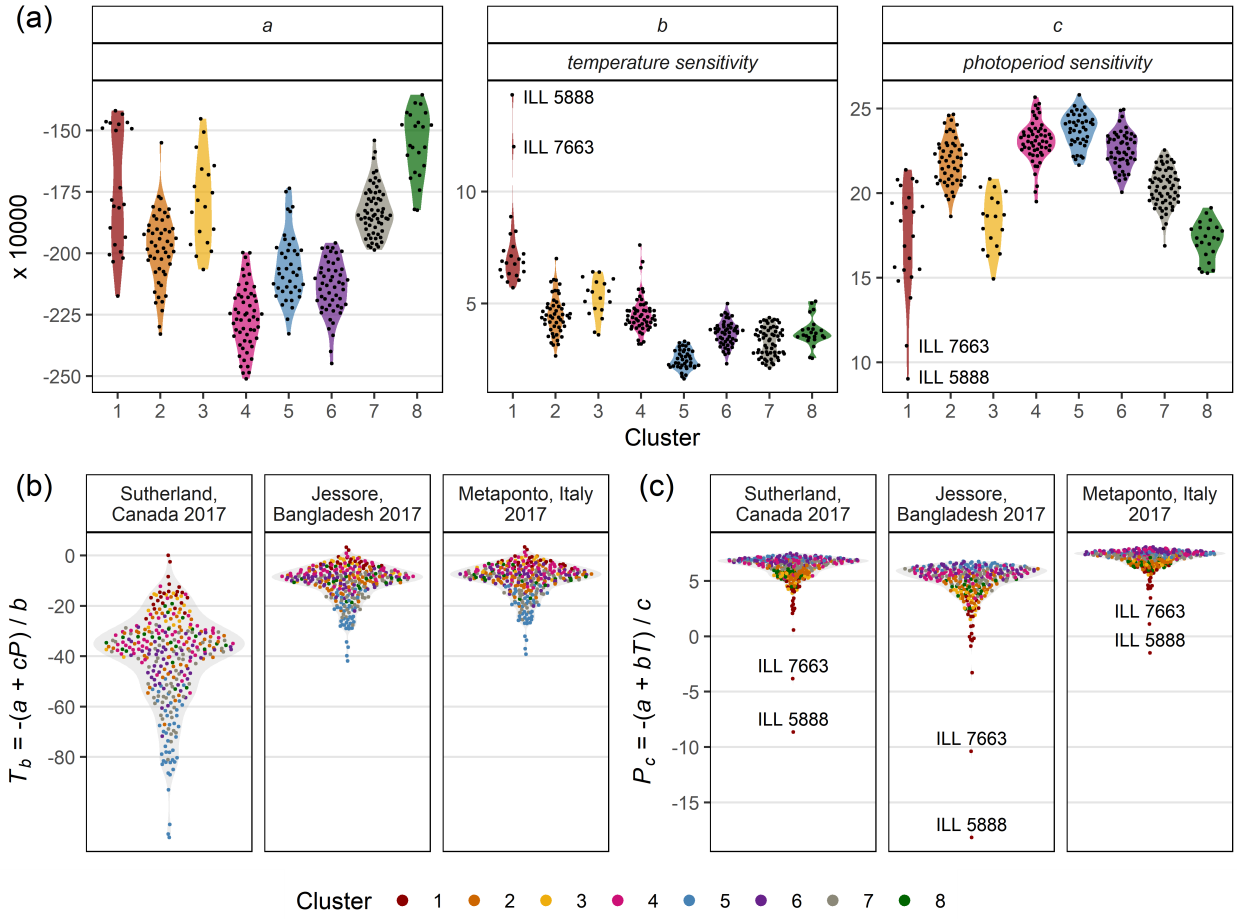


Figure 5: Photothermal constants along with nominal base temperatures and photoperiods for a lentil (Lens culinaris Medik.) diversity panel. (a) Distribution of a, b and c constants calculated from equation 1 among cluster groups. Estimates of: (b) nominal base temperature (Tb), and (c) nominal base photoperiod (Pc) based on equations 2 and 3, respectively, using the mean temperature (T) and photoperiod (P) from Sutherland, Canada 2017, Jessore, Bangladesh 2017 and Metaponto, Italy 2017.

Figure 6

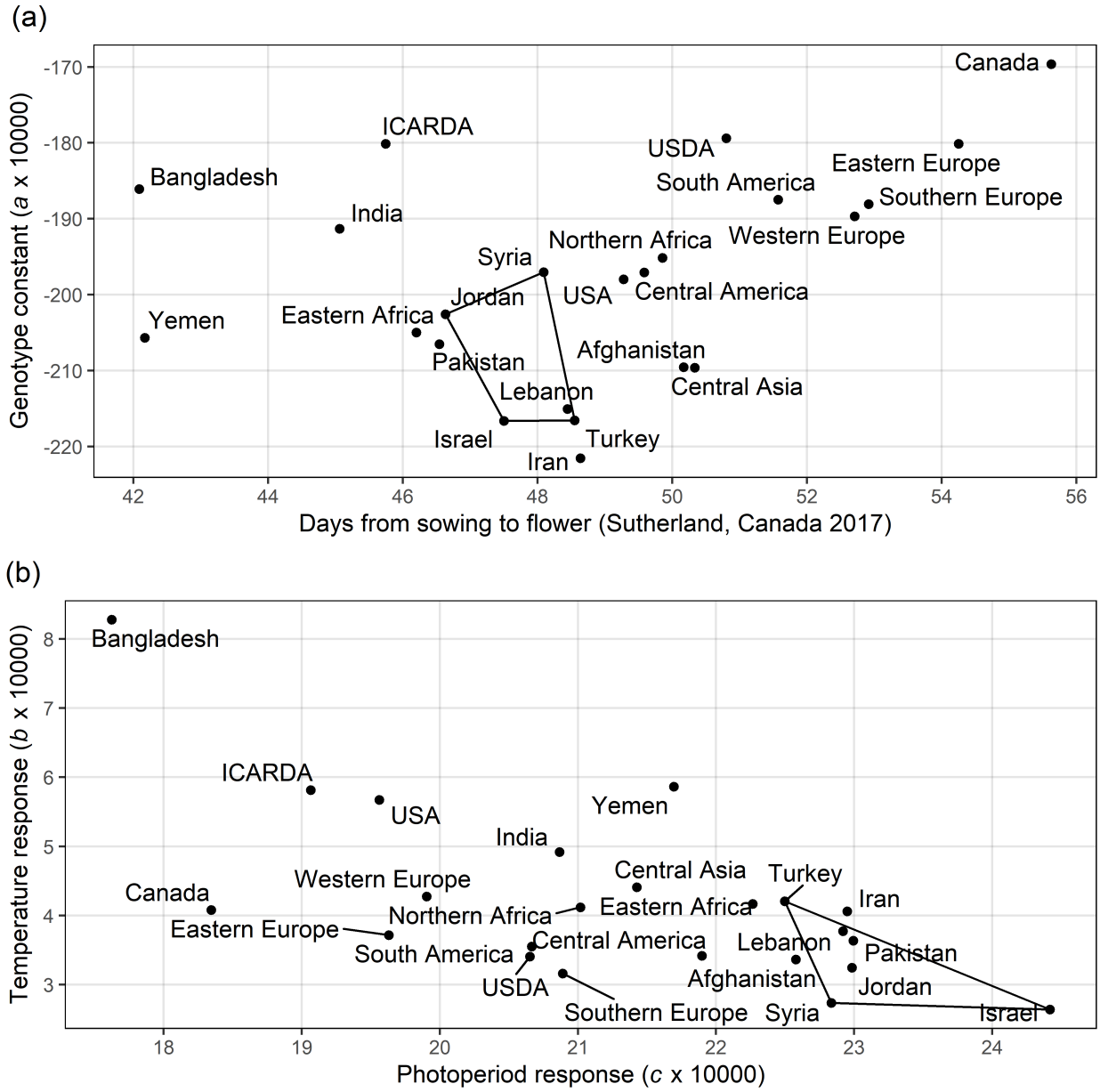


Figure 6: Photothermal responses of lentil (Lens culinaris Medik.) adapted to regions outside the center of origin. (a) Comparison of days from sowing to flowering in Sutherland, Canada 2017 and the genotype constant a (x 104) derived from equation 1. (b) Comparison of temperature response (b x 104) and photoperiod response (c x 104) derived from equation 1. Polygons represent the variation inherent in the region where the crop was domesticated.

Figure 7

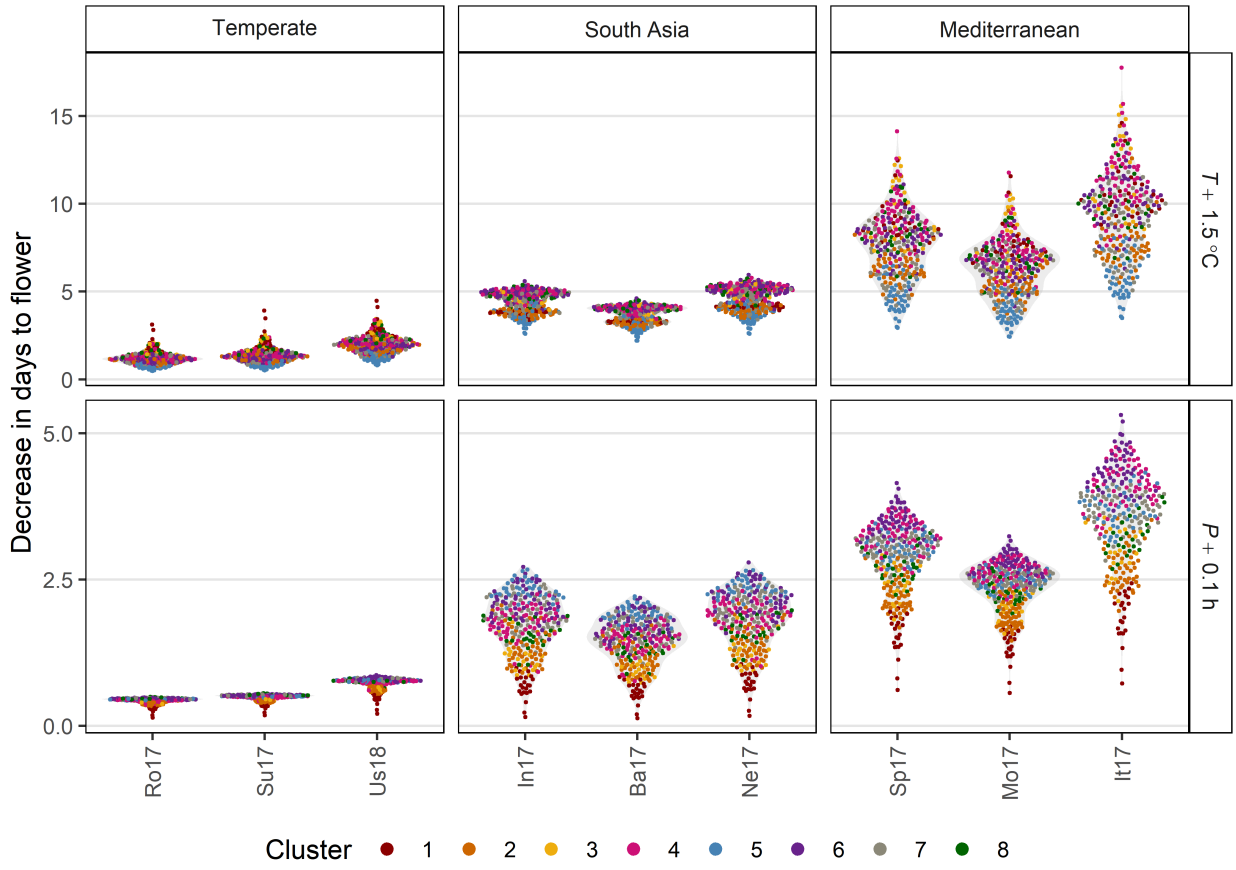


Figure 7: Predicted decrease in days from sowing to flowering for a lentil (Lens culinaris Medik.) diversity panel based on a mean temperature (T) or photoperiod (P) increases of 1.5oC or 0.1h using equation 1 in the selected locations: Rosthern, Canada 2017 (Ro17), Sutherland, Canada 2017 (Su17), Central Ferry, USA 2018 (Us18), Bhopal, India 2017 (In17), Jessore, Bangladesh 2017 (Ba17), Bardiya, Nepal 2017 (Ne17), Marchouch, Morocco 2017 (Mo17), Cordoba, Spain 2017 (Sp17) and Metaponto, Italy 2017 (It17).

Supplemental Figures

Supplemental Figure 1

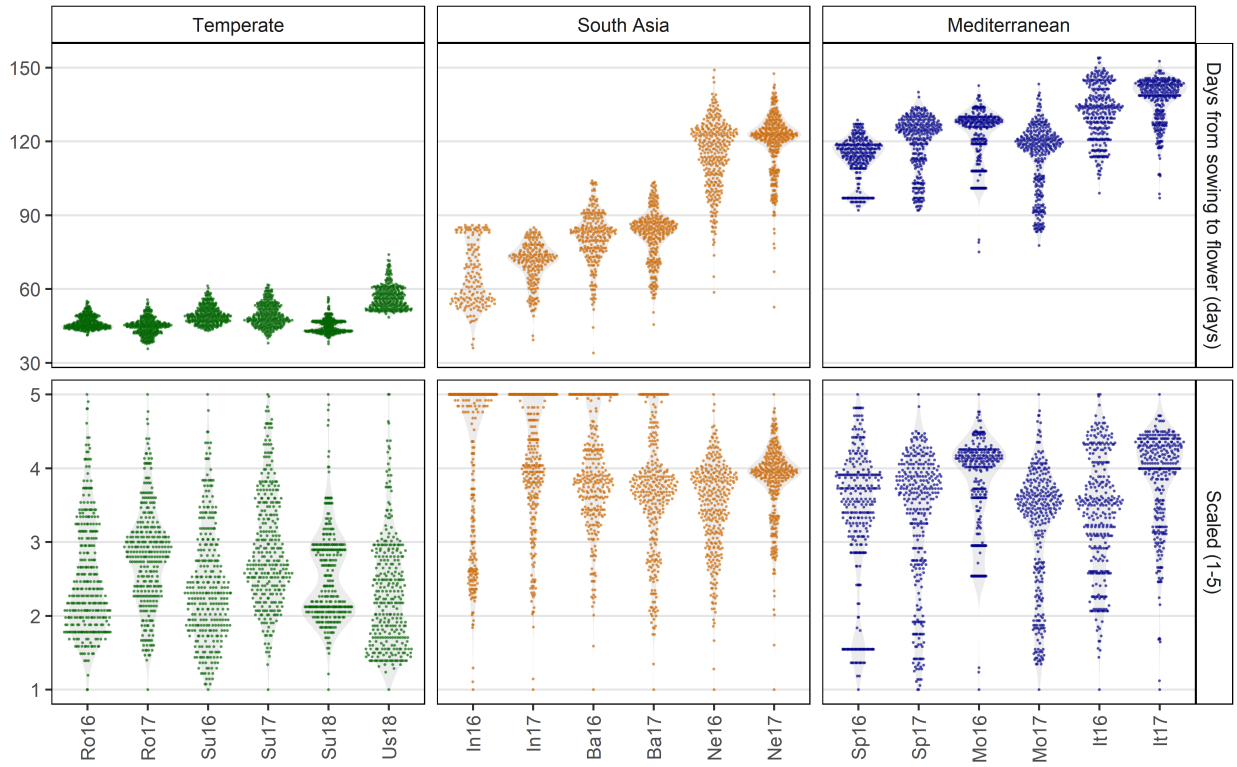


Figure S1: Distribution of days from sowing to flowering for raw data (top) and scaled data (1-5) (bottom) for all 18 field trials: Rosthern, Canada 2016 and 2017 (Ro16, Ro17), Sutherland, Canada 2016, 2017 and 2018 (Su16, Su17, Su18), Central Ferry, USA 2018 (Us18), Metaponto, Italy 2016 and 2017 (It16, It17), Marchouch, Morocco 2016 and 2017 (Mo16, Mo17), Cordoba, Spain 2016 and 2017 (Sp16, Sp17), Bhopal, India 2016 and 2017 (In16, In17), Jessore, Bangladesh 2016 and 2017 (Ba16, Ba17), Bardiya, Nepal 2016 and 2017 (Ne16, Ne17). Genotypes which did not flower were given a scaled value of 5.

Supplemental Figure 2

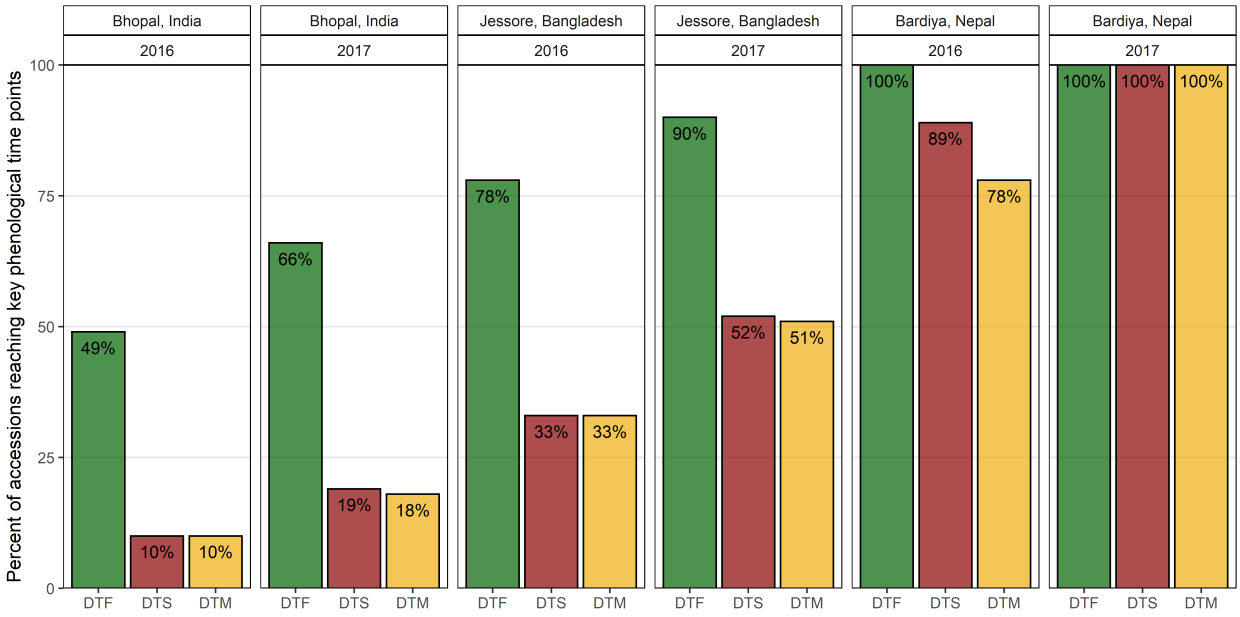


Figure S2: Percentage of lentil genotypes reaching key phenological time points in South Asian locations. Days from sowing to: flowering (DTF), swollen pods (DTS) and maturity (DTM).

Supplemental Figure 3

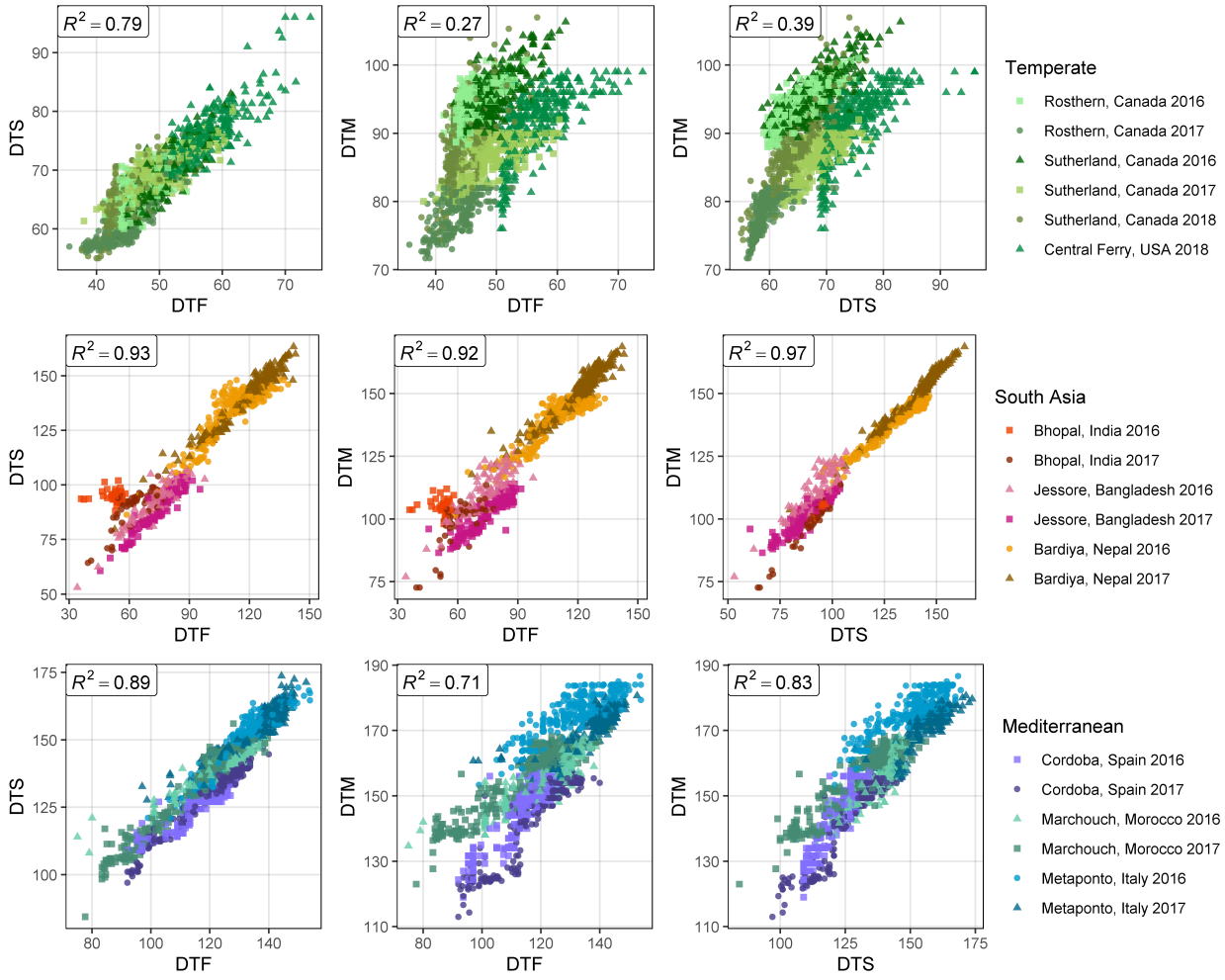


Figure S3: Correlations along with the corresponding correlation coefficients (R2) between days from sowing to: flowering (DTF), swollen pod (DTS) and maturity (DTM), in temperate (top), South Asian (middle) and Mediterranean (bottom) locations.

Supplemental Figure 4

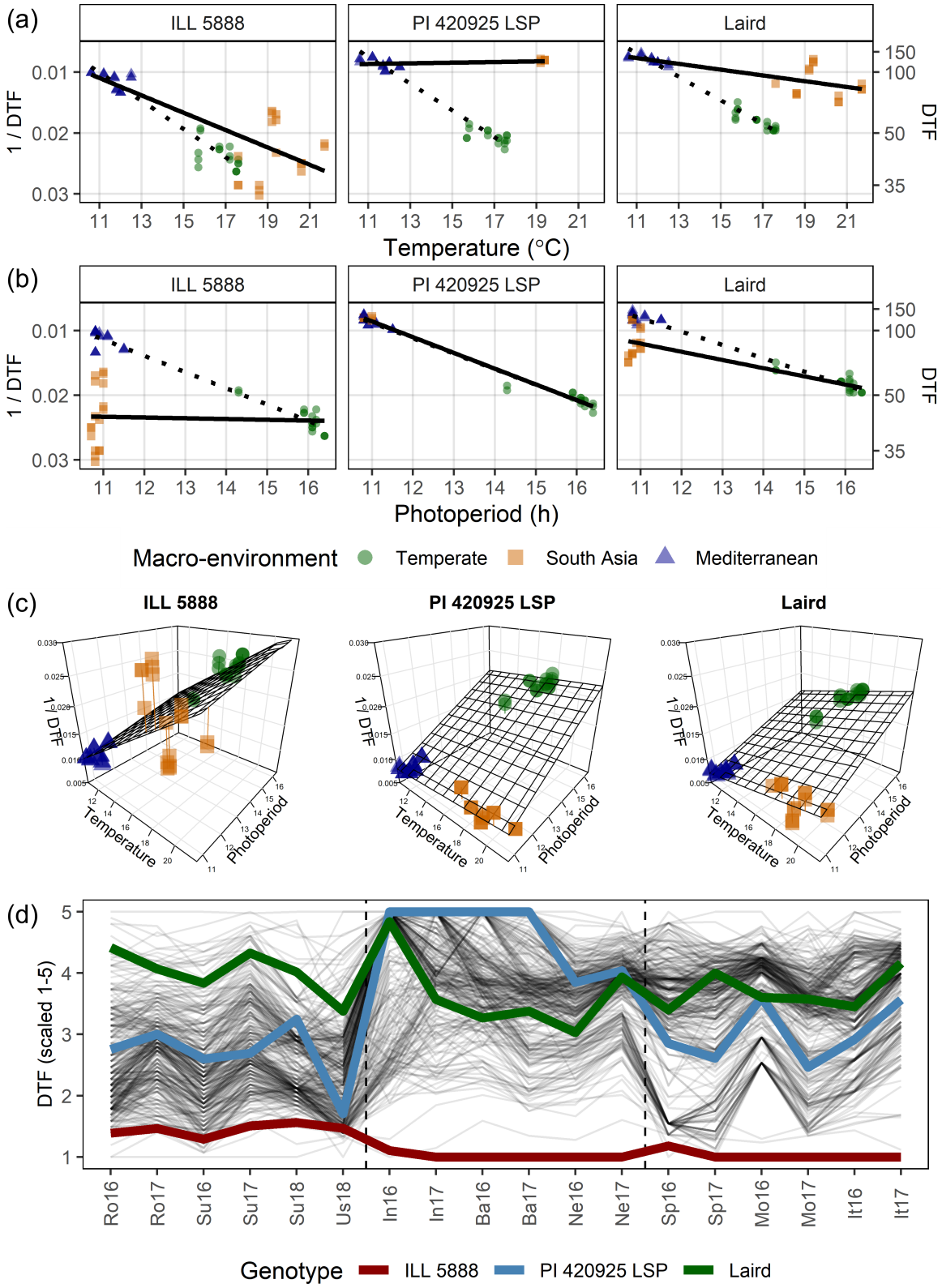


Figure S4: Effects of mean temperature and photoperiod on the rate of progress towards flowering (1 / DTF) in three contrasting selected genotypes. (a) Effect of temperature on 1 / DTF, (b) effect of photoperiod on 1 / DTF, and (c) effect of temperature and photoperiod on 1 / DTF modelled using equation 1. For (a) and (b), solid lines represent regressions among locations of relatively constant photoperiod or temperature, respectively, while dotted lines indicate a break in the assumption of constant photoperiod or temperature, respectively, across environments (see Figure 1). (d) Scaled DTF (1-5) of each genotype (grey lines) across all site-years with ILL5888, PI 420925 LSP and Laird highlighted according to their corresponding cluster group, 1, 5 and 8 respectively. ILL 5888 is an early maturing, genotype from Bangladesh. PI 420925 LSP is a landrace from Jordan with medium maturity. Laird is a late maturing, Canadian cultivar.

Supplemental Figure 5

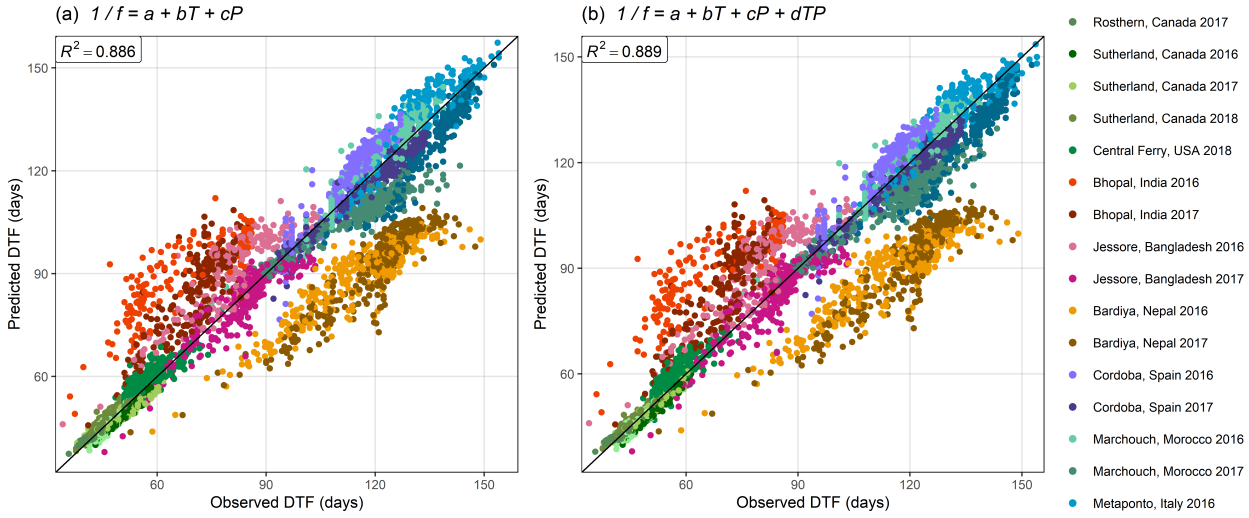


Figure S5: Comparison of observed and predicted values for days from sowing to flowering using (a) equation 1 and (b) equation 2.

Supplemental Figure 6

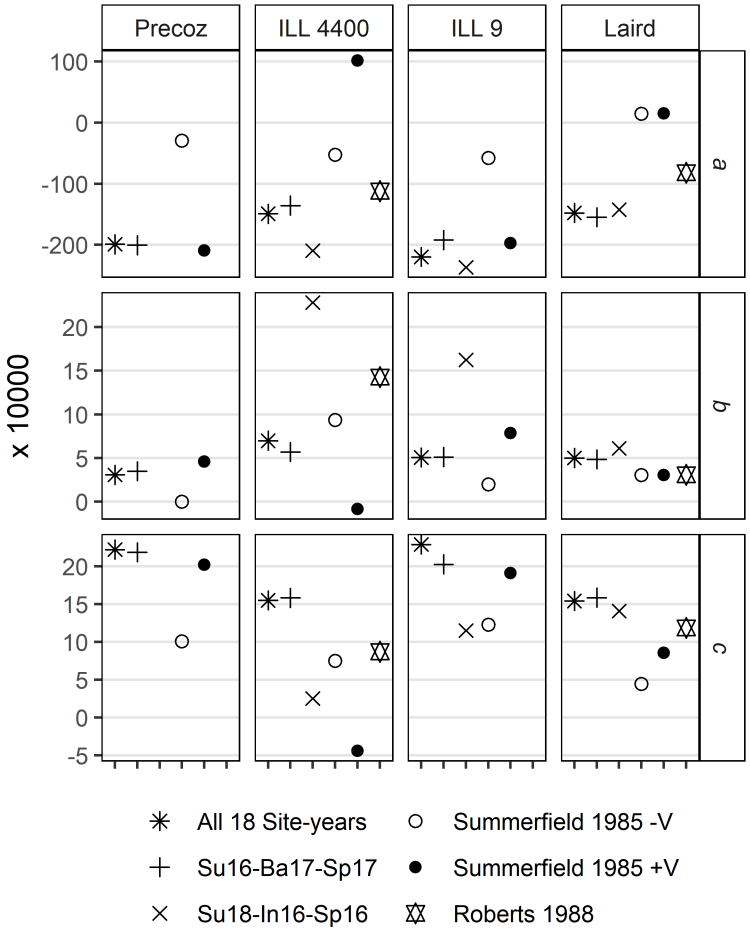


Figure S6: Comparison of a, b, and c constants calculated using equation 1, in the current study using all site-years, the three best site-years for predicting DTF, Sutherland, Canada 2016 (Su16), Jessore, Bangladesh 2017 (Ba17) and Cordoba, Spain 2017 (Sp17), the three worst site-years for predicting DTF, Sutherland, Canada 2018 (Su18), Bhopal, India 2016 (In16) and Cordoba, Spain 2016 (Sp16), from Roberts et al., (1988) and from Summerfield et al., (1985) with (+V) and without (-V) a seed vernalization treatment.

Supplemental Figure 7

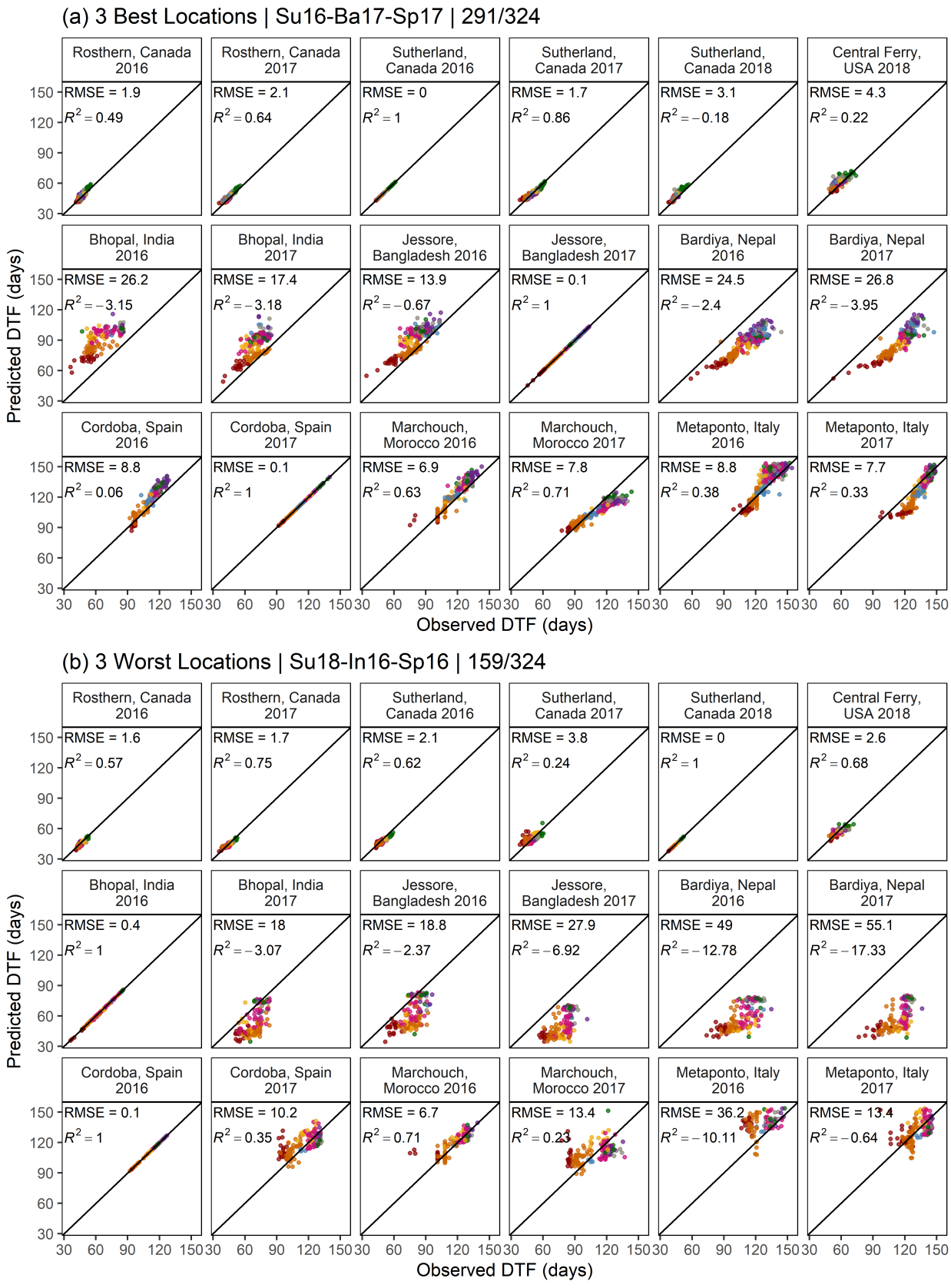


Figure S7: Comparison of observed and predicted values, along with the coefficient of determination (R2) and root-mean-square error (RMSE), for days from sowing to flowering, calculated using equation 1, with (a) the 3 best site-years for training the model and (b) the 3 worst years for training the model (see Table S4). Sutherland, Canada 2016 and 2018 (Su16, Su18), Cordoba, Spain 2016 and 2017 (Sp16, Sp17), Bhopal, India 2016 (In16) and Jessore, Bangladesh 2017 (Ba17). Predictions of DTF can only be made with genotypes that flowered in all three locations, therefore, predictions in (a) are based on 291 and in (b) based on 159 of 324 genotypes used in this study.

Supplemental Figure 8

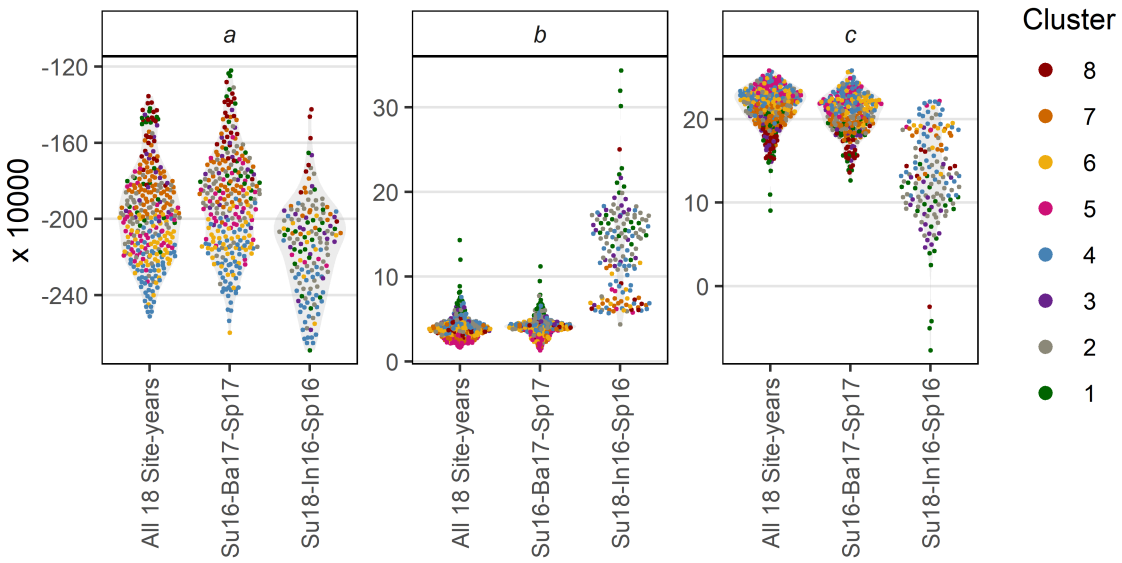


Figure S8: Comparison of a, b, and c constants calculated using equation 1 using all site-years, the three best site-years for predicting DTF, Sutherland, Canada 2016 (Su16), Jessore, Bangladesh 2017 (Ba17) and Cordoba, Spain 2017 (Sp17), and the three worst site-years for predicting DTF, Sutherland, Canada 2018 (Su18), Bhopal, India 2016 (In16) and Cordoba, Spain 2016 (Sp16).

Supplemental Figure 9

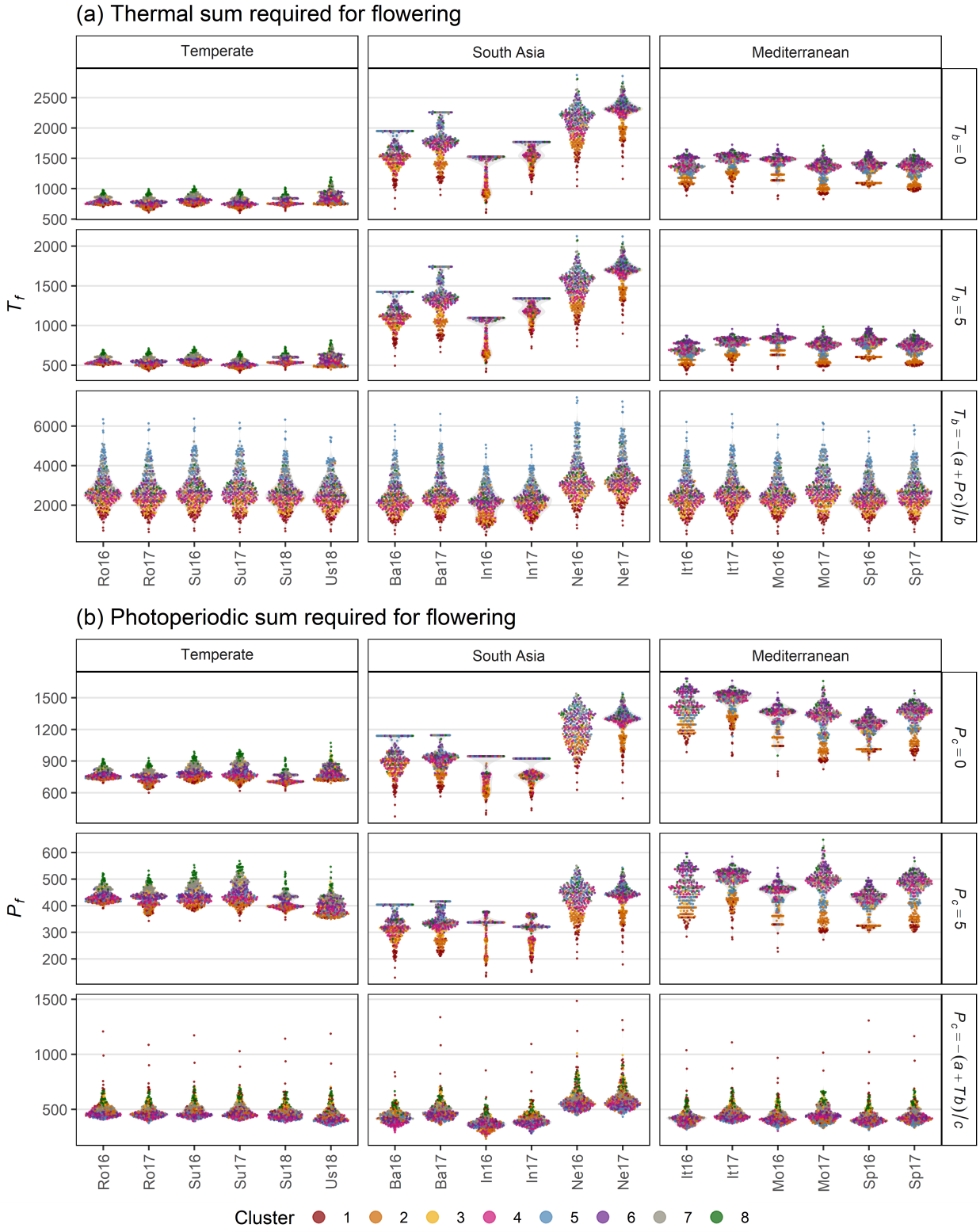


Figure S9: (a) Thermal sum required for flowering (Tf), using a base temperature (Tb) of 0°C, 5°C and calculated using equation 3, across all site-years. (b) Photoperiodic sum required for flowering (Pf), using a critical photoperiod (Pc) of 0h, 5h and calculated using equation 4, across all site-years. Rosthern, Canada 2016 and 2017 (Ro16, Ro17), Sutherland, Canada 2016, 2017 and 2018 (Su16, Su17, Su18), Central Ferry, USA 2018 (Us18), Metaponto, Italy 2016 and 2017 (It16, It17), Marchouch, Morocco 2016 and 2017 (Mo16, Mo17), Cordoba, Spain 2016 and 2017 (Sp16, Sp17), Bhopal, India 2016 and 2017 (In16, In17), Jessore, Bangladesh 2016 and 2017 (Ba16, Ba17), Bardiya, Nepal 2016 and 2017 (Ne16, Ne17).

Supplemental Figure 10

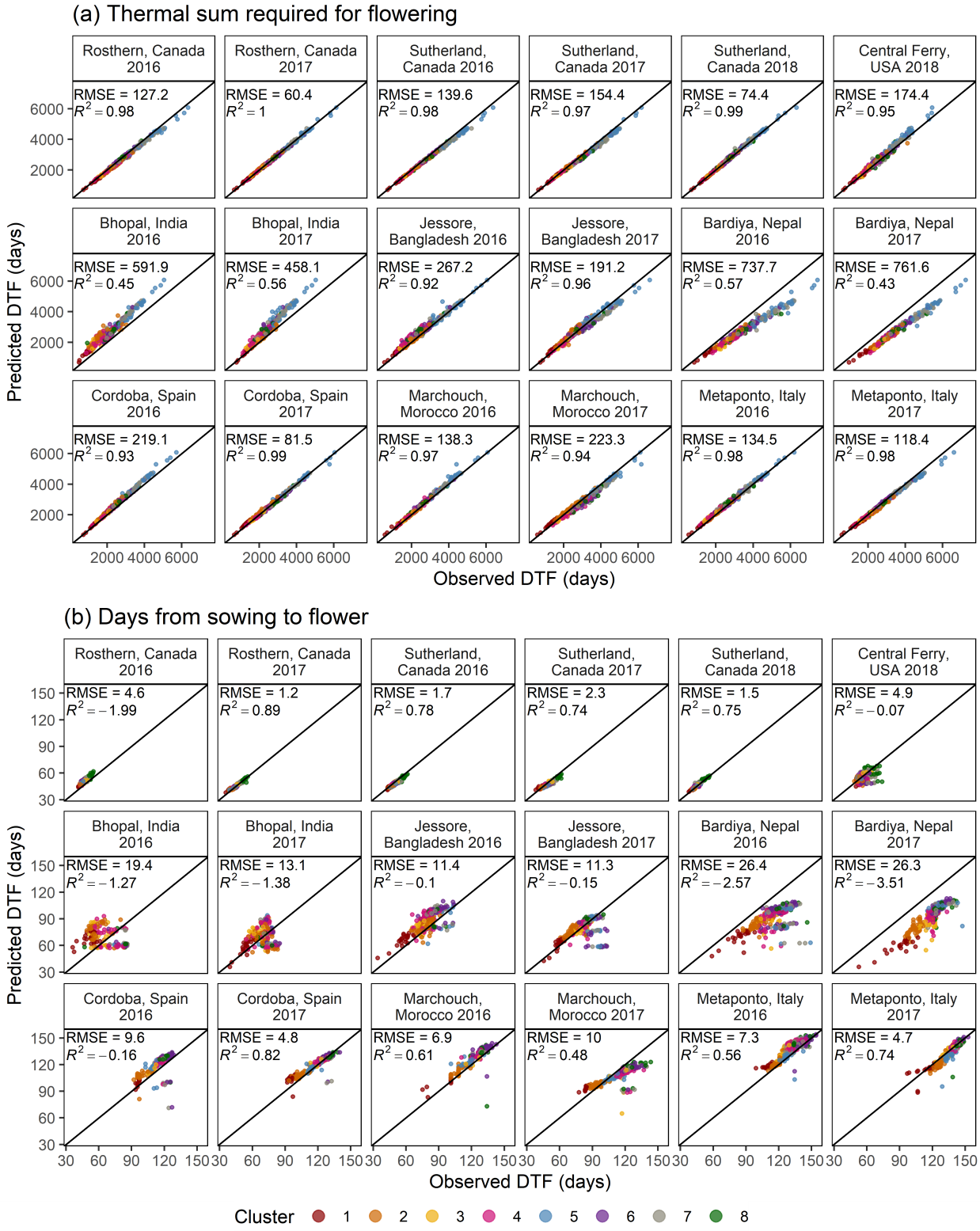


Figure S10: Comparison of observed vs predicted values, along with the coefficient of determination (R2) and root-mean-square error (RMSE), for (a) thermal sum required for flowering and (b) days from sowing to flowering, calculated using equation 5.

Supplemental Figure 11

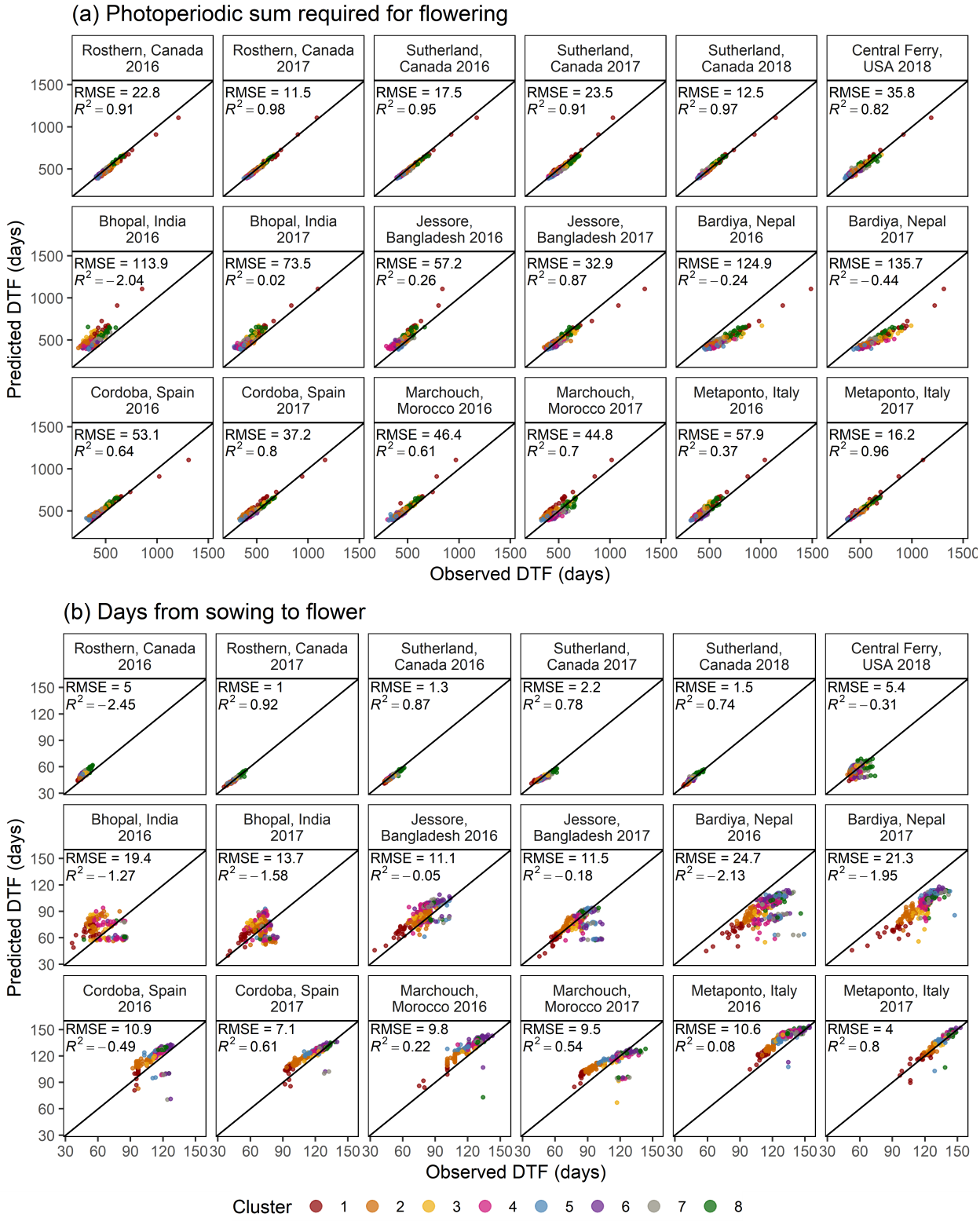


Figure S11: Comparison of observed vs predicted values, along with the coefficient of determination (R2) and root-mean-square error (RMSE) for (a) photoperiodic sum required for flowering and (b) days from sowing to flowering, calculated using equation 6.

Supplemental Tables

Supplemental Table 1

Supplemental_Table_01.csv

Show 10 entries Search:

	Entry	Name	Origin	Source	Synonyms
1	1	CDC Asterix AGL	Canada	USASK	
2	2	CDC Rosie AGL	Canada	USASK	
3	3	3156-11 AGL	Canada	USASK	
4	4	CDC Greenstar AGL	Canada	USASK	
5	5	CDC Cherie AGL	Canada	USASK	
6	6	CDC Glamis AGL	Canada	USASK	
7	7	CDC Gold AGL	Canada	USASK	
8	8	CDC Imax AGL	Canada	USASK	
9	9	CDC Impower AGL	Canada	USASK	
10	10	CDC KR-1 AGL	Canada	USASK	

Showing 1 to 10 of 324 entries Previous 1 2 3 4 5 … 33 Next

Table S1: Genotype entry number, name, common synonyms, origin and source of lentil genotypes used in this study. These genotypes are gathered from the University of Saskatchewan (USASK), Plant Gene Resources of Canada (PGRC), United States Department of Agriculture (USDA), International Center for Agricultural Research in the Dry Areas (ICARDA).

Supplemental Table 2

Supplemental_Table_02.csv

Show 10 entries Search:

	Location	Year	Short.Name	Latitude	Longitude	Planting.Date	Temperature..mean.	Photoperiod..mean.	Number.of.Seeds.Sown	Plot.Type
1	Sutherland, Canada	2016	Su16	52.1677	-106.5054	2016-04-27	16.7	15.9	60	three, 1 meter rows
2	Rosthern, Canada	2016	Ro16	52.6892	-106.2945	2016-05-06	17.2	16.2	60	three, 1 meter rows
3	Marchouch, Morocco	2016	Mo16	33.62	-6.72	2016-11-21	12	10.8	25	one, 1 meter row
4	Cordoba, Spain	2016	Sp16	37.9	-4.8	2016-12-13	12.5	10.9	25	one, 1 meter row
5	Metaponto, Italy	2016	It16	40.39	16.78	2016-11-29	10.6	10.8	25	one, 1 meter row
6	Bhopal, India	2016	In16	23.11	76.88	2016-12-04	17.6	10.9	25	one, 1 meter row
7	Bardiya, Nepal	2016	Ne16	28.25	81.5	2016-11-14	19.2	11	25	one, 1 meter row
8	Jessore, Bangladesh	2016	Ba16	23.19	89.19	2016-11-15	18.6	10.8	25	one, 1 meter row
9	Sutherland, Canada	2017	Su17	52.16832	-106.5108	2017-05-04	15.7	16.1	70	three, 1 meter rows
10	Rosthern, Canada	2017	Ro17	52.6915	-106.2897	2017-05-19	17.5	16.4	70	three, 1 meter rows

Showing 1 to 10 of 18 entries Previous 1 2 Next

Table S2: Details of the field trials used in this study, including location information, planting dates, mean temperature and photoperiods and details on plot type and number of seeds sown.

Supplemental Table 3

Supplemental_Table_03.csv

Show 10 entries Search:

	Entry	Name	a	b	c	d	RR	Environments	a_p.value	b_p.value	c_p.value	d_p.value
1	1	CDC Asterix AGL	-0.0187716662822634	0.000337218421340274	0.00204558652125348		0.897834658449581	16	2.4104450958207e-21	5.428928612786936-8	3.67737730460217e-31	
2	1	CDC Asterix AGL	0.00726931004137411	-0.00120170671575862	-0.000317378218248454	0.000139733215875025	0.899282743849064	16	6.620203243727153	0.16883515574063 9	0.8110850090864 36	0.07939746933690 76
3	2	CDC Rosie AGL	-0.0146750282064116	0.000352470560585572	0.00169075691987598		0.8459236201684	18	1.99187258047008e-15	2.764375494811172e-7	1.07031693317471e-24	
4	2	CDC Rosie AGL	0.0209252132424467	-0.00175206235807338	-0.00153402249683015	0.000190738184307775	0.843227951762813	18	0.168610844096879	0.0534282068426557	0.2627385584666 65	0.02125918272771 64
5	3	3156-11 AGL	-0.0138803729777879	0.000356250257589655	0.00158730410706612		0.88276584969854	16	3.050032959615 2e-18	3.332210145109 08e-10	4.75980854197144e-29	
6	3	3156-11 AGL	0.0110193544071	-0.00111492554971737	-0.000677165043405088	0.000133881748828031	0.884412590817312	16	0.390569271707208	0.143903982897601	0.5603757471707 5	0.05536029811245 66
7	4	CDC Greenstar AGL	-0.0154056470321614	0.000429344832951	0.00168912844577084		0.820583864394007	17	3.555326291917 04e-16	1.378531230093 69e-9	6.854645145473 63e-26	
8	4	CDC Greenstar AGL	-0.00719484222155549	-0.000056070403756035 8	0.000943995714008215	0.000044096712351342	0.818997987159103	17	0.665595196530187	0.954462120736397	0.5318337687245 66	0.62084320508743 6
9	5	CDC Cherie AGL	-0.0174208378413679	0.000394818141746095	0.00190886594317692		0.831963143249369	17	2.82102648175384e-17	5.540646814276 96e-8	1.20146925953831e-26	
10	5	CDC Cherie AGL	0.00116715998447523	-0.000704085348511522	0.000221971468480789	0.000099829902351018 9	0.830582540753126	17	0.945642405337202	0.487141632944902	0.8862218855081 92	0.27898345706092 1

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Table S3: Values of the constants derived from equations 1 and 2 using data from all site-years, for each of the genotypes used in this study.

Supplemental Table 4

Supplemental_Table_04.csv

Show 10 entries Search:

	Temperate_Location	SouthAsian_Location	Mediterranean_Location	RR	Genotypes
1	Ro17	In16	Sp16	0.46177	159
2	Su18	In16	Sp16	0.462242	159
3	Ro16	In16	Sp16	0.466809	159
4	Su17	In16	Sp16	0.469932	159
5	Su16	In16	Sp16	0.473691	159
6	Ro17	In16	It17	0.47592	159
7	Su18	In16	It17	0.476053	159
8	Ro16	In16	It17	0.47995	159
9	Us18	In16	Sp16	0.486316	159
10	Su17	In16	It17	0.487061	159

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Table S4: All possible combinations of a single temperate, South Asian, and Mediterranean site-year, used to train the model, with equation 1, along with the corresponding coefficient of determination (RR = R2), and number of genotypes which flowered in all three site-years.

Data Results Files

PCA

PCA Results (data/data_pca_results.csv)

Show 10 entries Search:

	Entry	Name	Origin	Region	Cluster	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
1	1	CDC Asterix AGL	Canada	Americas	7	3.54448236194707	0.440814288712303	0.0751601069104444	-0.111979676108047	-0.0593582625304431	-0.00733081469782029	0.807736373404227	-0.779843824404834	0.252931546296276	0.254186891473437
2	2	CDC Rosie AGL	Canada	Americas	8	3.52849023924396	3.67895312692245	0.505575228054782	-0.159873300075634	-0.594672386034304	0.239648588167101	-0.318371834244006	-0.0107815320089239	0.108677907796985	0.0106650557217046
3	3	3156-11 AGL	Canada	Americas	8	5.62048372566636	4.42412235530683	0.560729505173675	0.902765982260623	-0.0932141337933211	0.540757076327601	-0.161601441039477	0.271542686496069	0.293413640960653	-0.0230653566162944
4	4	CDC Greenstar AGL	Canada	Americas	7	2.07983342535076	3.09109401471844	0.457309961248602	-0.0570958838340037	0.0870138884609766	-1.20507088866338	0.121814610278861	-0.207994548219819	0.204449191969456	0.455578968235245
5	5	CDC Cherie AGL	Canada	Americas	7	1.60541961735283	1.4005642361084	0.721149977077666	-0.324237972033567	-0.963523166286033	-0.647046166002189	0.514704239787553	-0.153193940022535	0.281244527109426	0.376785944079598
6	6	CDC Glamis AGL	Canada	Americas	8	3.41720812576708	2.98954645180697	0.26551015308113	0.102251010035259	-0.115104542509517	-0.597087990883338	-0.564505957535235	0.0544034834726121	0.0380013216613088	0.202474176326796
7	7	CDC Gold AGL	Canada	Americas	7	3.40421804727935	0.917123114654413	0.00122145215633442	-0.448242041980569	0.197285293177474	-0.671342316674389	0.505389427870582	-0.0854367839462367	0.159619477696679	1.123102881369 41
8	8	CDC Imax AGL	Canada	Americas	7	2.34140193606314	-0.283278141845045	1.03328561510757	-0.124298922622988	0.0716885999368045	0.254601972897785	0.107185362430554	-0.784455472218944	-0.260602529590832	0.300022702837176
9	9	CDC Impower AGL	Canada	Americas	7	2.67463170075799	1.77423026062778	-0.530561602977272	-0.0394369217048207	-0.117591636124683	-0.679718290152805	0.232444339012874	-0.611115430810592	0.0622583220844317	0.107562420560678
10	10	CDC KR-1 AGL	Canada	Americas	3	1.53117653664273	4.11130060611086	-0.802031402395143	-0.668106732646195	-0.956634122512524	-0.303115556878948	-0.139116714031839	0.0206280402337334	0.905163905976973	-0.298476089717168

Showing 1 to 10 of 324 entries Previous 1 2 3 4 5 … 33 Next

PhotoThermal Model

Photothermal Model Results (data/data_model_t+p_coefs.csv)

Show 10 entries Search:

	Entry	Name	a	b	c	RR	Environments	aP	bP	cP
1	1	CDC Asterix AGL	-0.0187716662822634	0.000337218421340274	0.00204558652125348	0.897834658449581	16	2.4104450958207e-21	5.42892861278693e-8	3.67737730460217e-31
2	2	CDC Rosie AGL	-0.0146750282064116	0.000352470560585572	0.00169075691987598	0.8459236201684	18	1.99187258047008e-15	2.764375494811726-7	1.0703169331747 1e-24
3	3	3156-11 AGL	-0.0138803729777879	0.000356250257589655	0.00158730410706612	0.88276584969854	16	3.05003295961526-18	3.33221014510908e-10	4.759808541971444e-29
4	4	CDC Greenstar AGL	-0.0154056470321614	0.000429344832951	0.00168912844577084	0.820583864394007	17	3.555326291917046-16	1.378531230093696-9	6.85464514547363e-26
5	5	CDC Cherie AGL	-0.0174208378413679	0.000394818141746095	0.00190886594317692	0.831963143249369	17	2.82102648175384e-17	5.540646814276696e-8	1.20146925953831e-26
6	6	CDC Glamis AGL	-0.01561627916672	0.000382506193320 76	0.00173496043070313	0.833369371206163	17	1.977549306203 7e-17	8.54728150678823e-9	2.594073705432 42e-27
7	7	CDC Gold AGL	-0.0181937958037976	0.000414708187995799	0.00191209477656577	0.86912142554116	16	6.267769393665 34e-19	2.182261091037 95e-9	1.67727273686028e-27
8	8	CDC Imax AGL	-0.0194152400169632	0.000279758748490445	0.00218850274315379	0.907819276291 44	16	2.111899136690 71e-22	0.000001803514550911 15	9.5189442879529e-33
9	9	CDC Impower AGL	-0.0175066489321135	0.000382788043520127	0.00190004378252379	0.875524869407973	17	1.550155749287 61e-19	1.058983383359 89e-8	6.559382345080 37e-29
10	10	CDC KR-1 AGL	-0.0150687008495716	0.000588140365103193	0.00149319213192524	0.691224248414617	18	1.115666896488 12e-9	3.129725561312 45e-8	1.011414336251 31e-15

Showing 1 to 10 of 324 entries Previous 1 2 3 4 5 … 33 Next

Base Temperature and Photoperiod

Nominal Base Temperature and Photoperiod (data/data_tb_pc.csv)

Climate Change

Response to Temperature or Photoperiod increases (data/data_temp_photo_increase.csv)

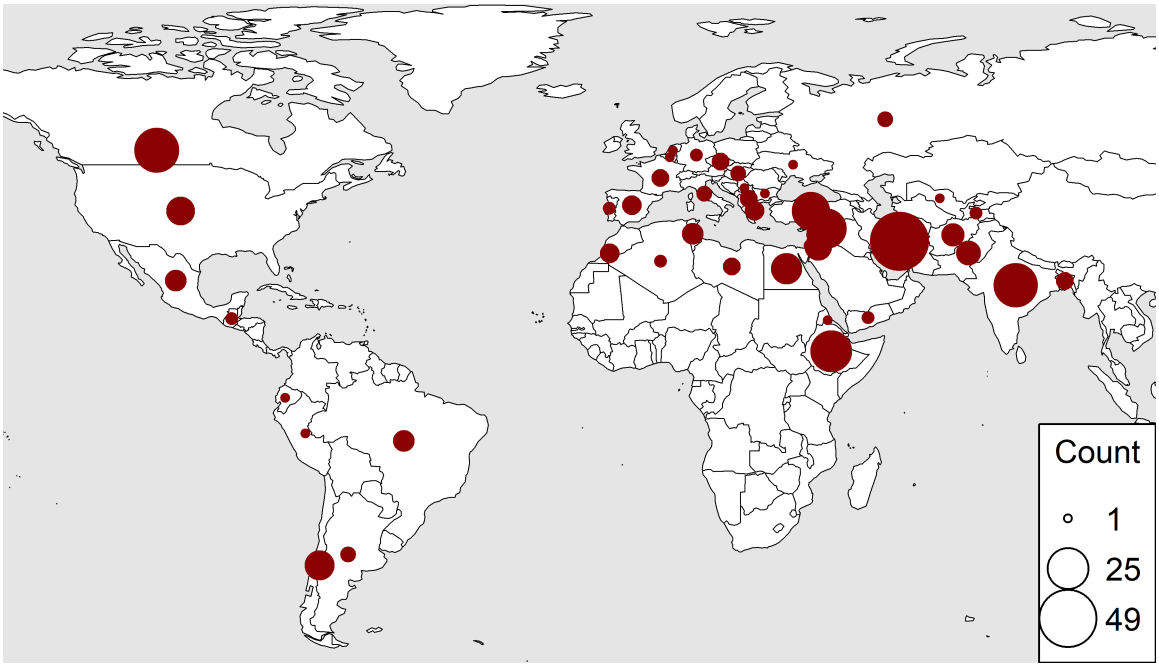
Show 10 entries Search:

	Expt	ExptShort	MacroEnv	Entry	Name	Cluster	DTF_0	DTF_1	Difference	Treatment
1	Rosthern, Canada 2017	Ro17	Temperate	1	CDC Asterix AGL	7	48.3622720149379	47.2074377155898	1.1548342993481	T + 1.5
2	Sutherland, Canada 2017	Su17	Temperate	1	CDC Asterix AGL	7	51.3964256590688	50.0940928442478	1.30233281482098	T + 1.5
3	Central Ferry, USA 2018	Us18	Temperate	1	CDC Asterix AGL	7	63.2580207486172	61.2966710262216	1.96134972239559	T + 1.5
4	Bhopal, India 2017	In17	South Asia	1	CDC Asterix AGL	7	99.3758305964465	94.6195840776218	4.75624651882474	T + 1.5
5	Jessore, Bangladesh 2017	Ba17	South Asia	1	CDC Asterix AGL	7	90.5188297168106	86.5557098946154	3.96311982219524	T + 1.5
6	Bardiya, Nepal 2017	Ne17	South Asia	1	CDC Asterix AGL	7	101.392056960723	96.4456577624086	4.94639919831415	T + 1.5
7	Cordoba, Spain 2017	Sp17	Mediterranean	1	CDC Asterix AGL	7	126.90678018893	119.251663394704	7.65511679422529	T + 1.5
8	Marchouch, Morocco 2017	Mo17	Mediterranean	1	CDC Asterix AGL	7	114.524500041428	108.253416775039	6.27108326638891	T + 1.5
9	Metaponto, Italy 2017	It17	Mediterranean	1	CDC Asterix AGL	7	140.894394051639	131.521110989358	9.3732830622809	T + 1.5
10	Rosthern, Canada 2017	Ro17	Temperate	2	CDC Rosie AGL	8	52.0247510526207	50.6320758204092	1.3926752322115	T + 1.5

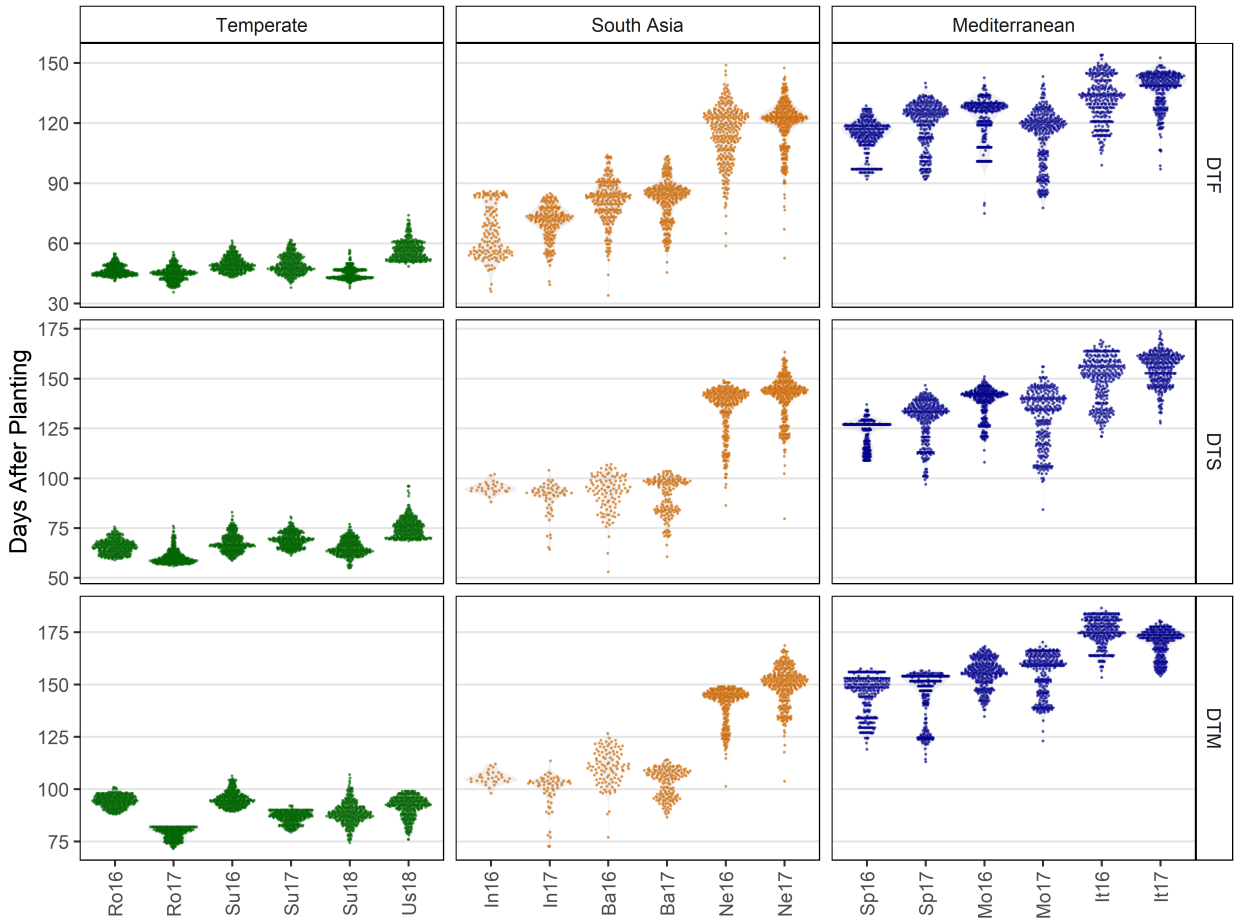
Showing 1 to 10 of 5,832 entries Previous 1 2 3 4 5 … 584 Next

Additional Figures

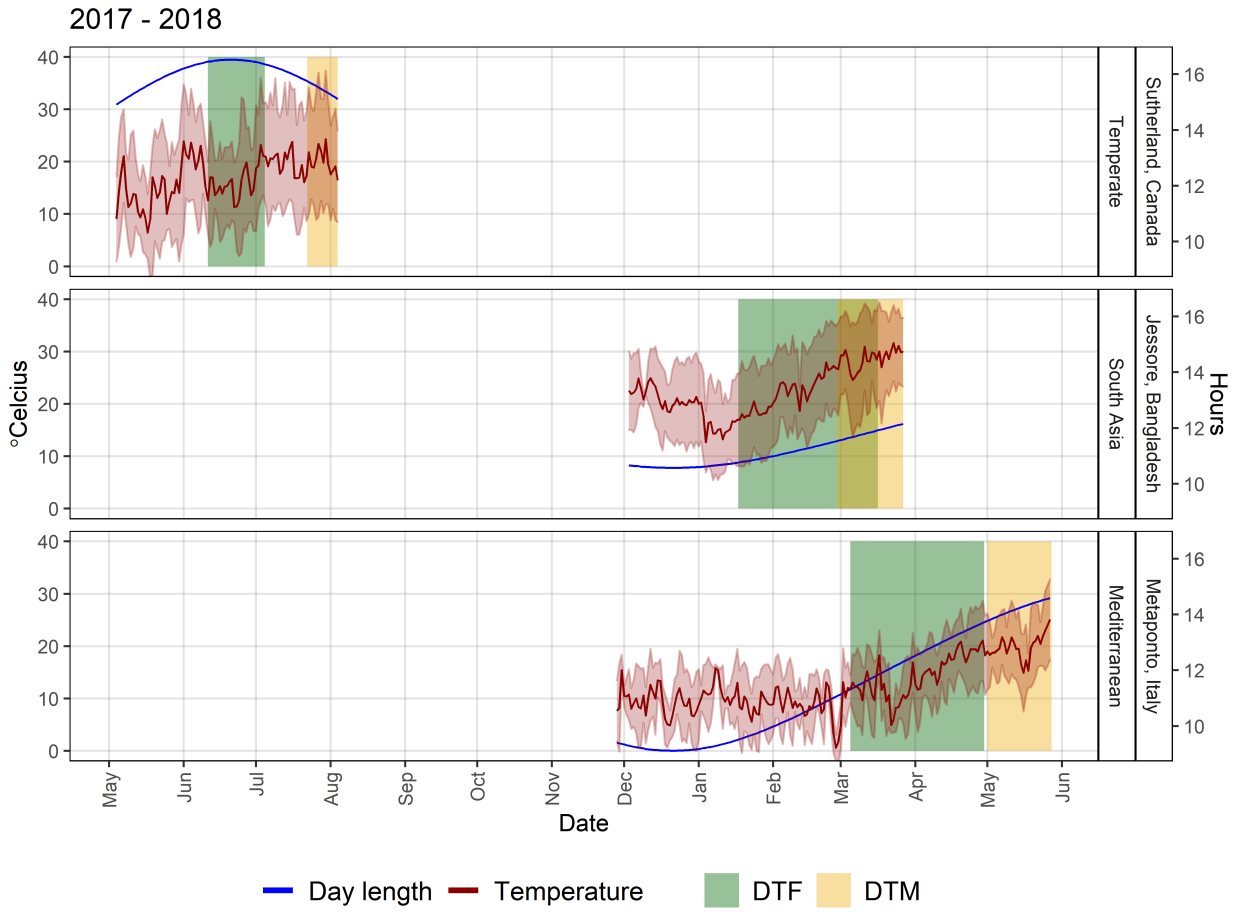
Additional Figure 1



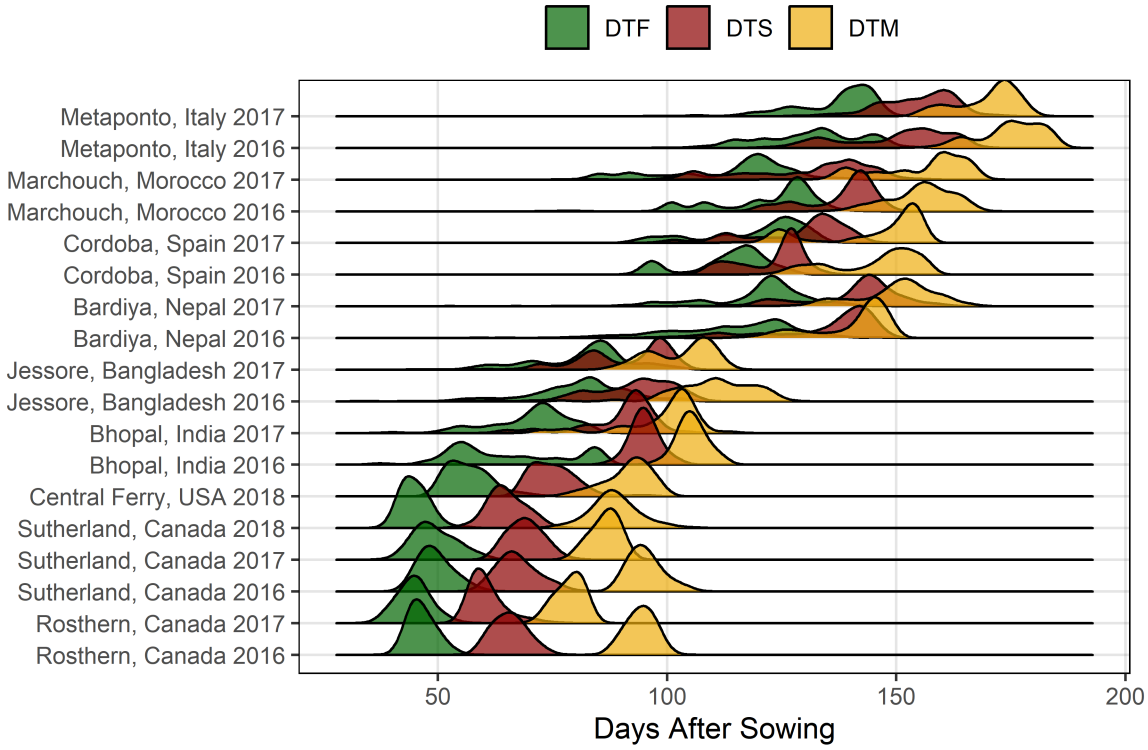
Additional Figure 2



Additional Figure 3

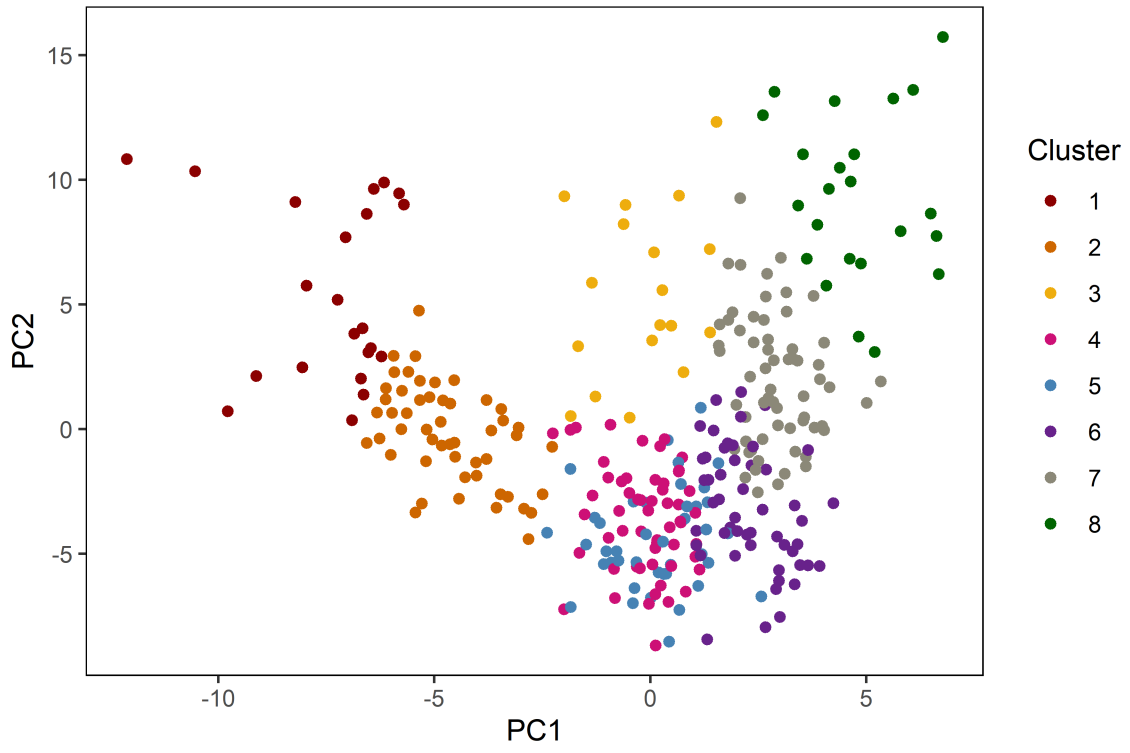


Additional Figure 4



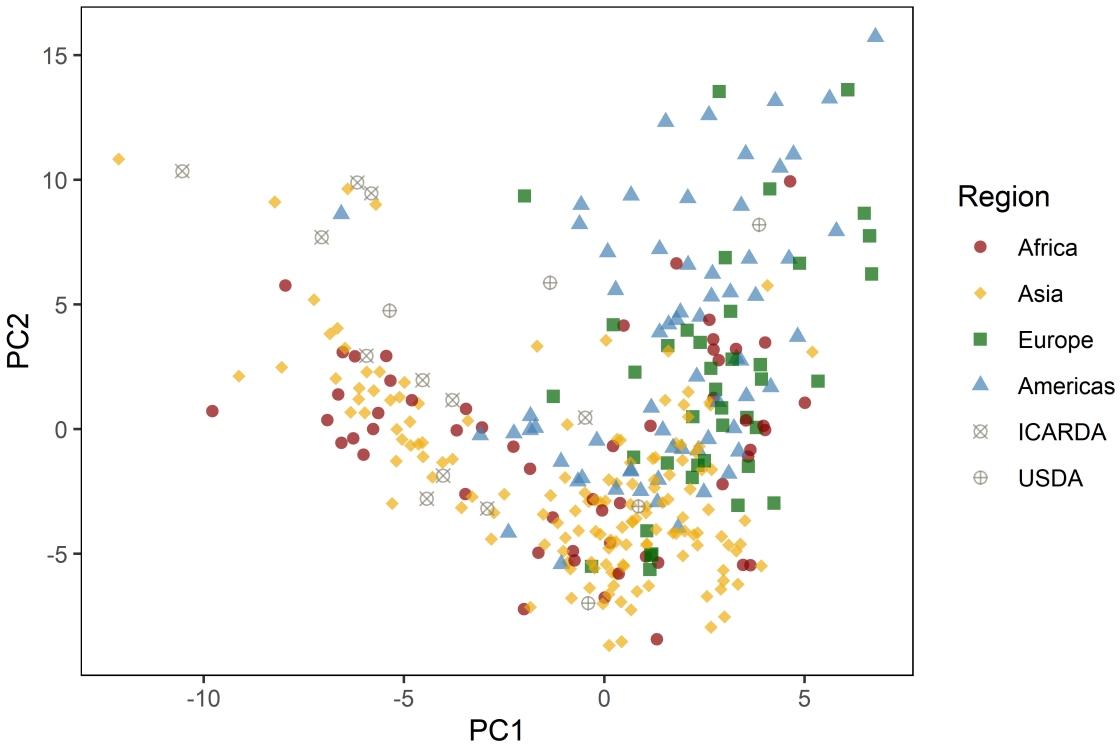
Additional Figure 5

Additional/Additional_Figure_05.html

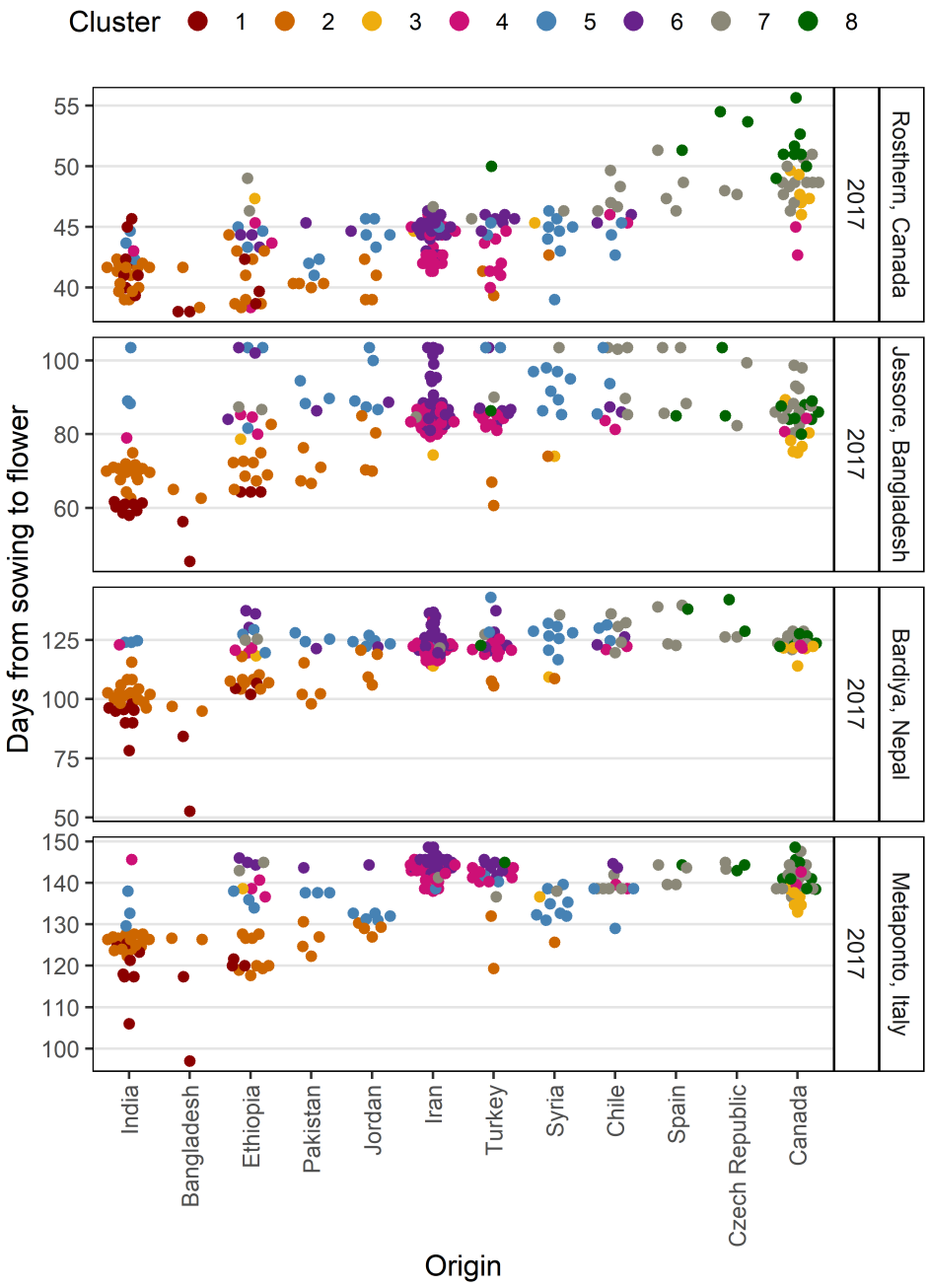


Additional Figure 6

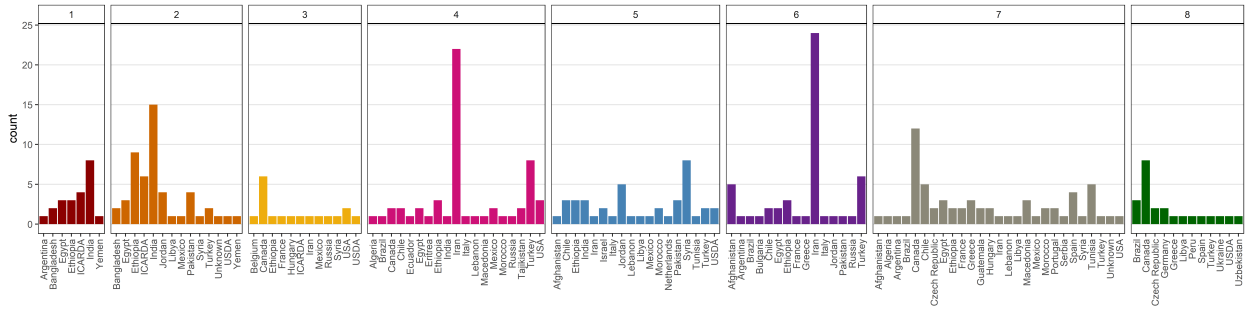
Additional/Additional_Figure_06.html



Additional Figure 7

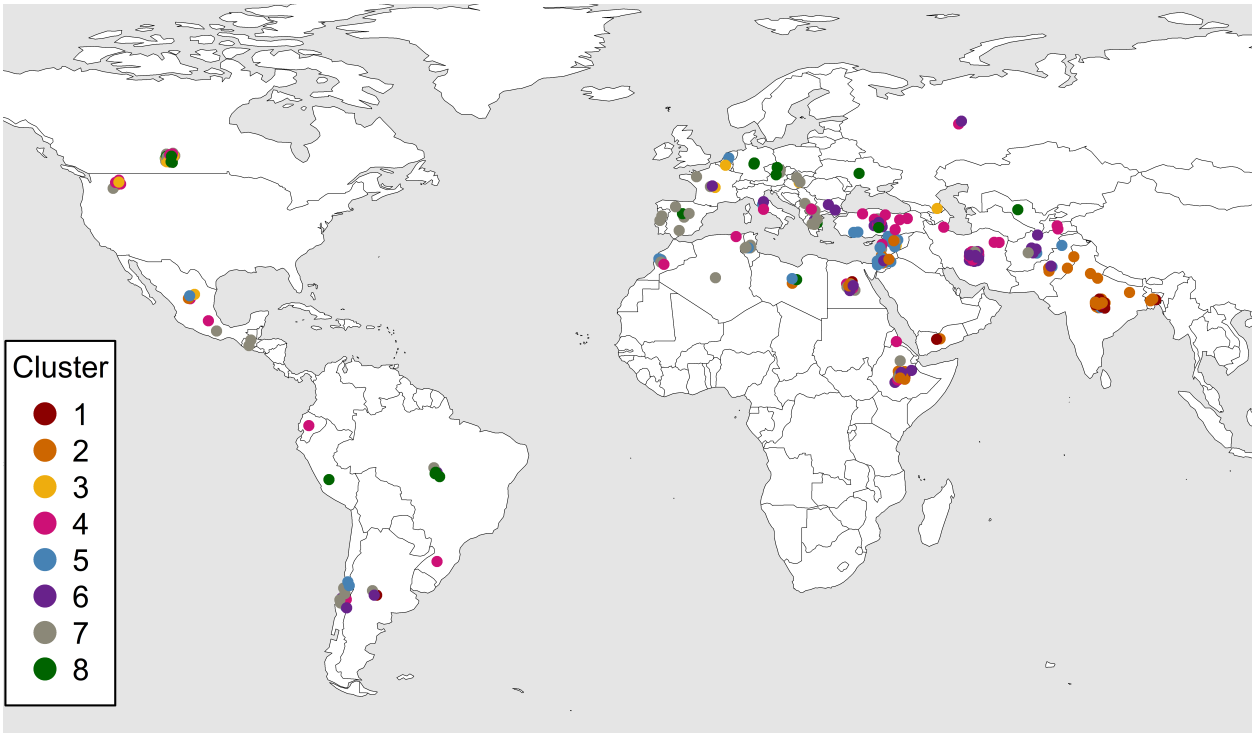


Additional Figure 8

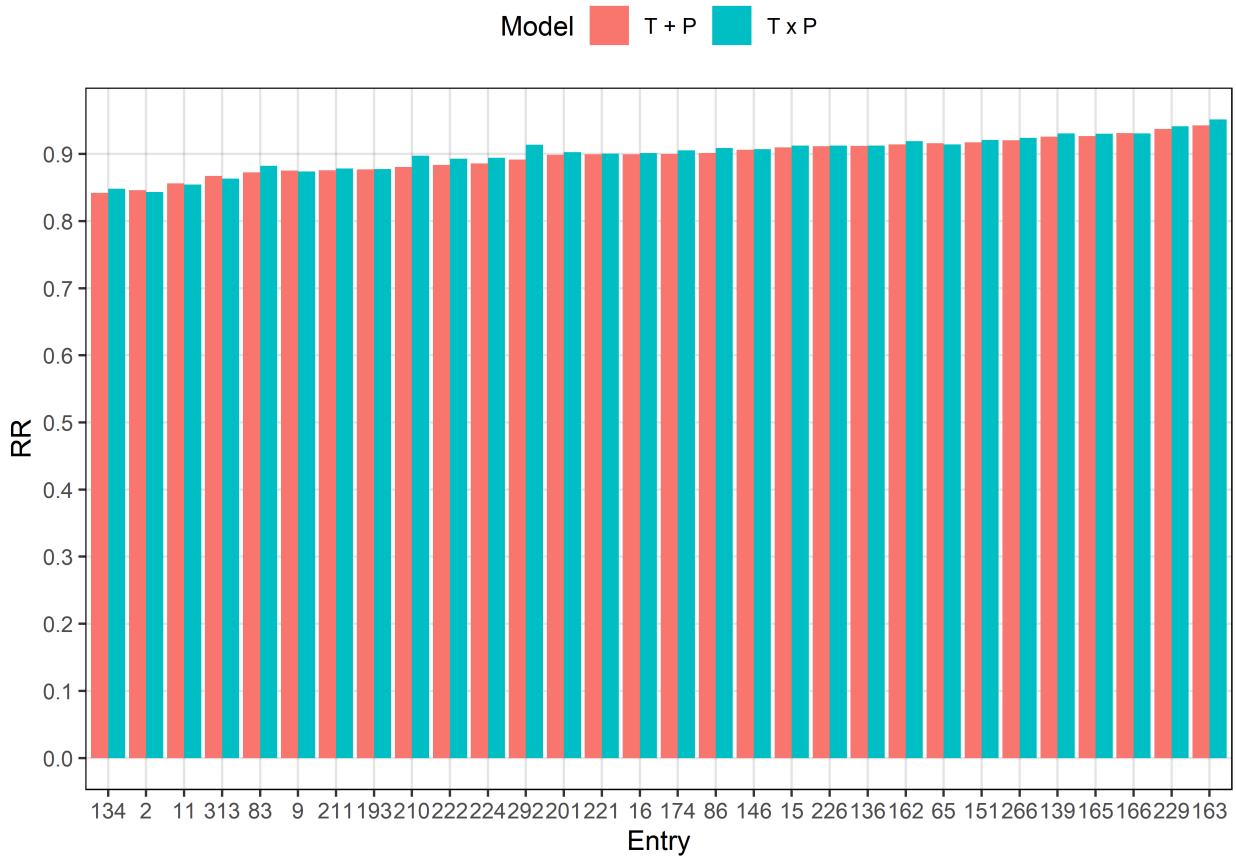


Additional Figure 9

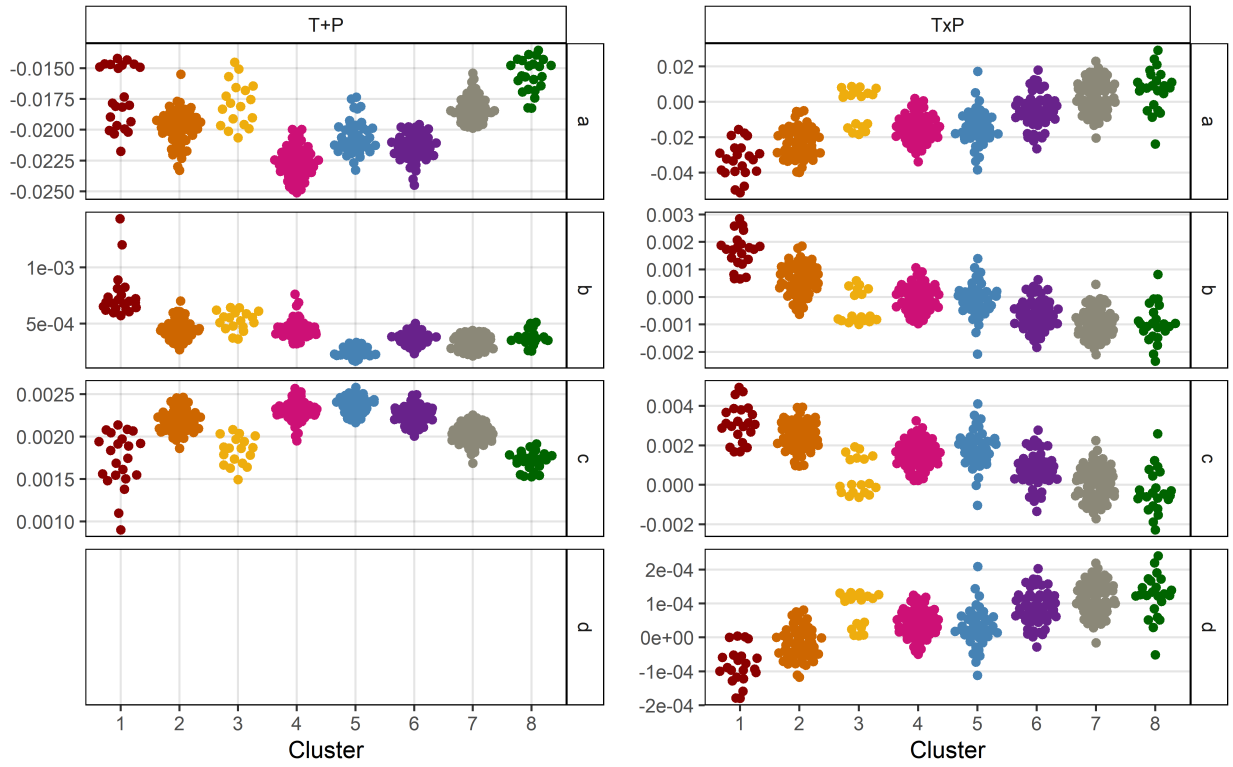
Additional/Additional_Figure_09.html



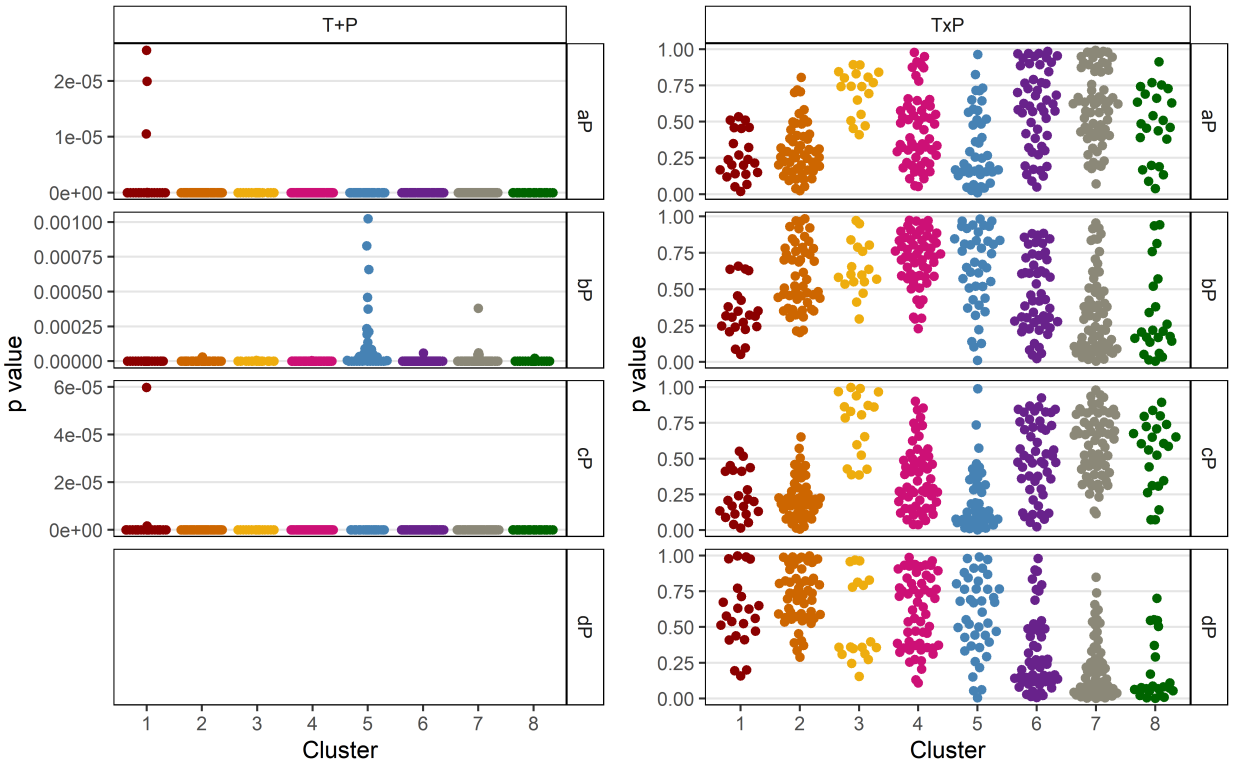
Additional Figure 10



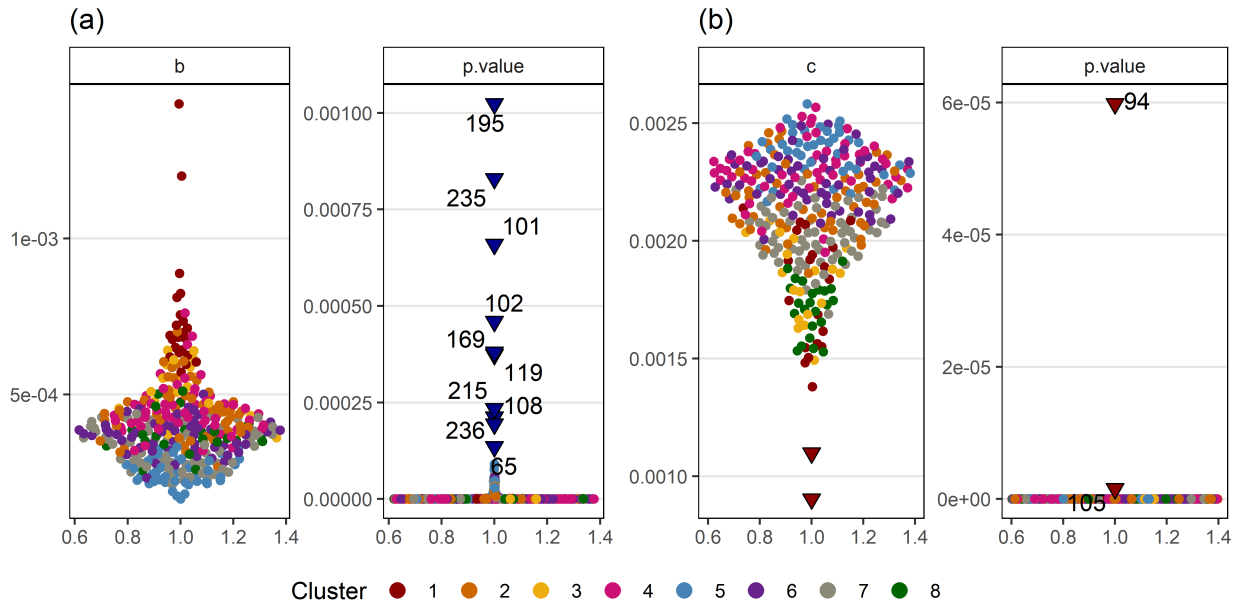
Additional Figure 11



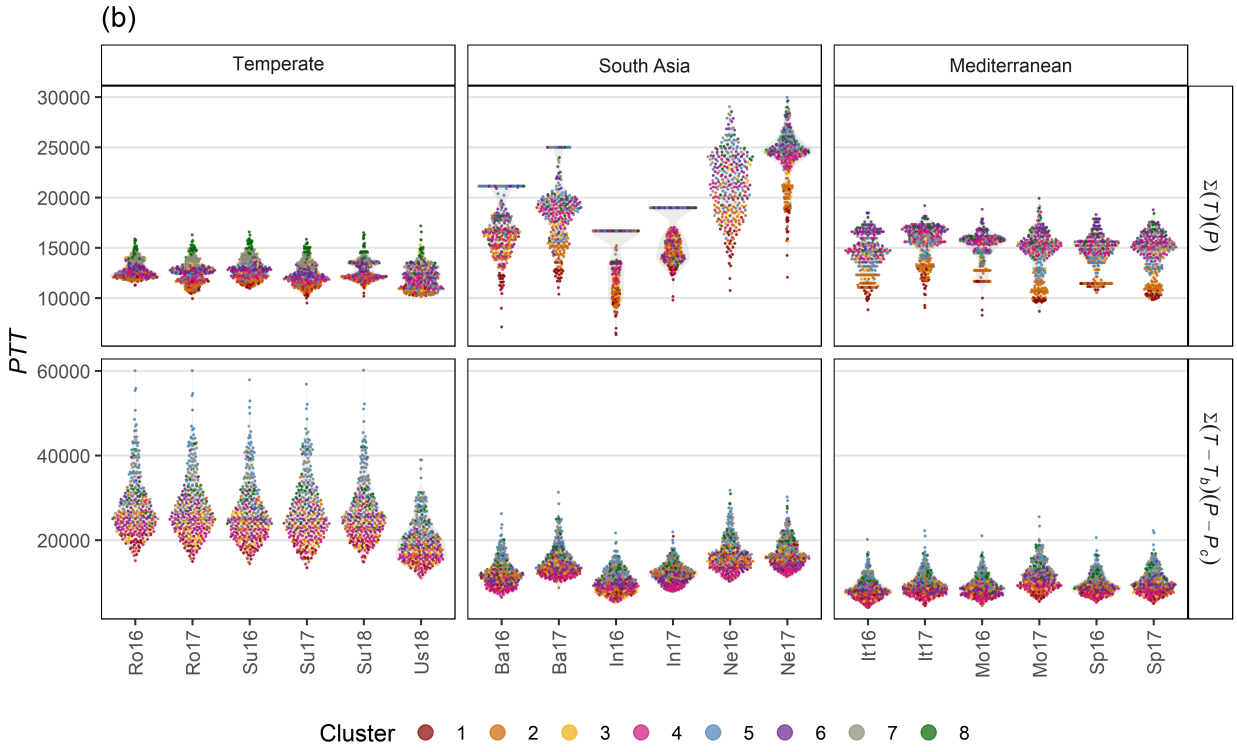
Additional Figure 12



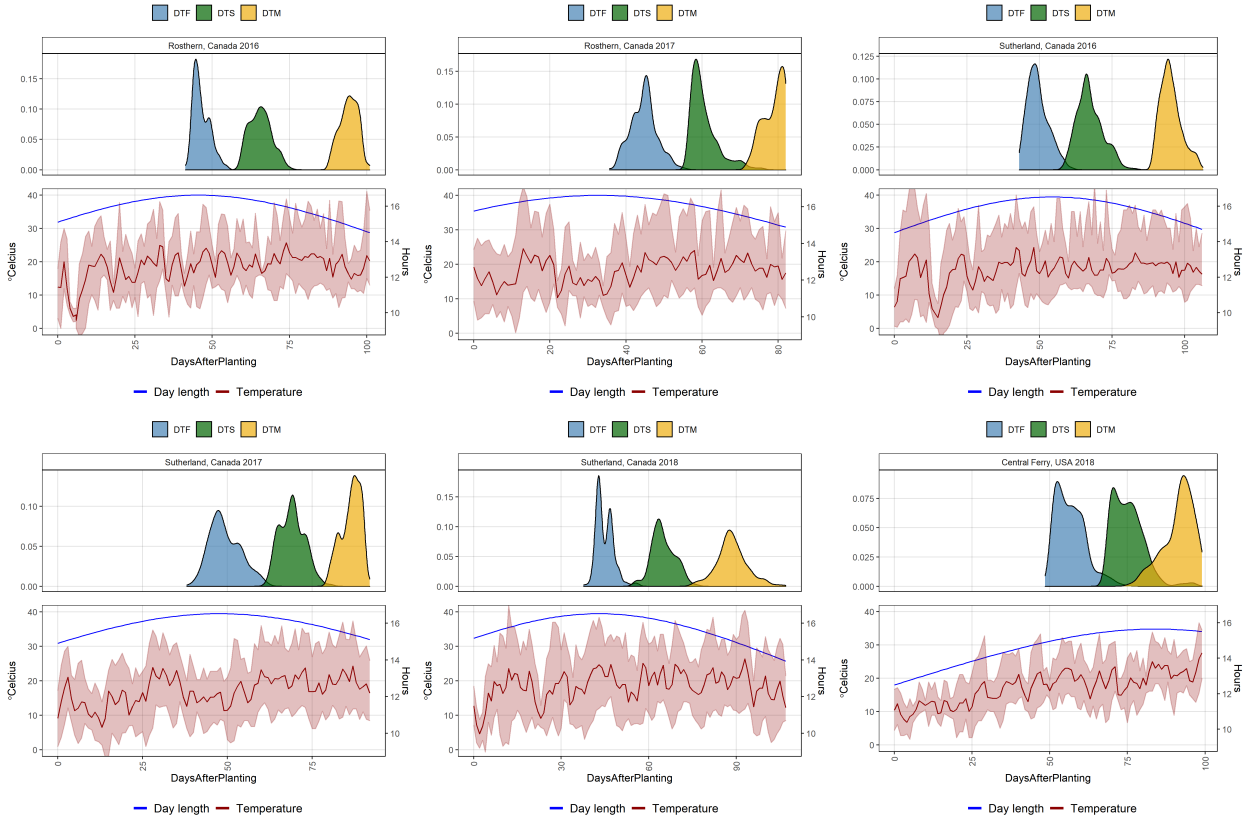
Additional Figure 13

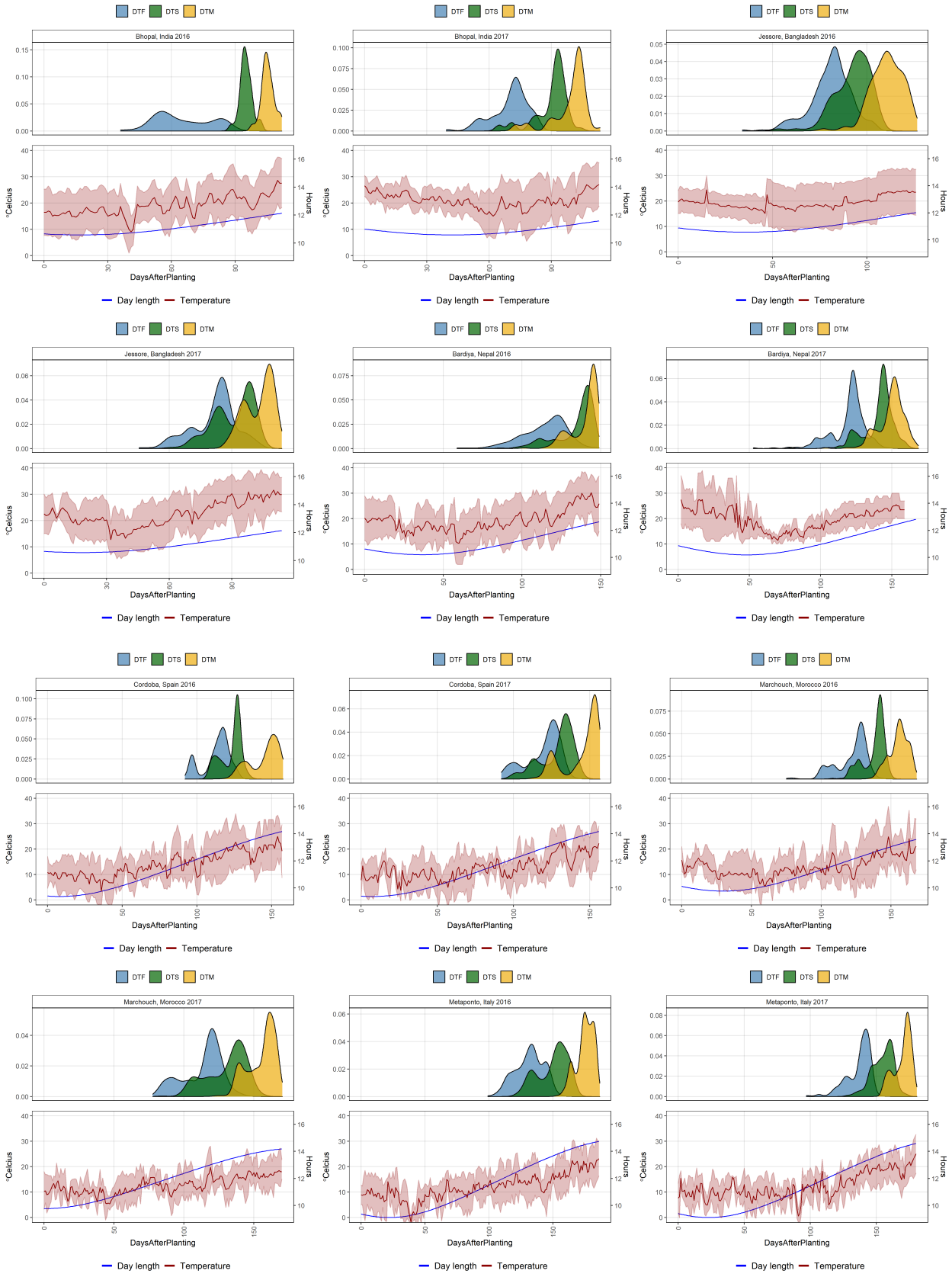


Additional Figure 14

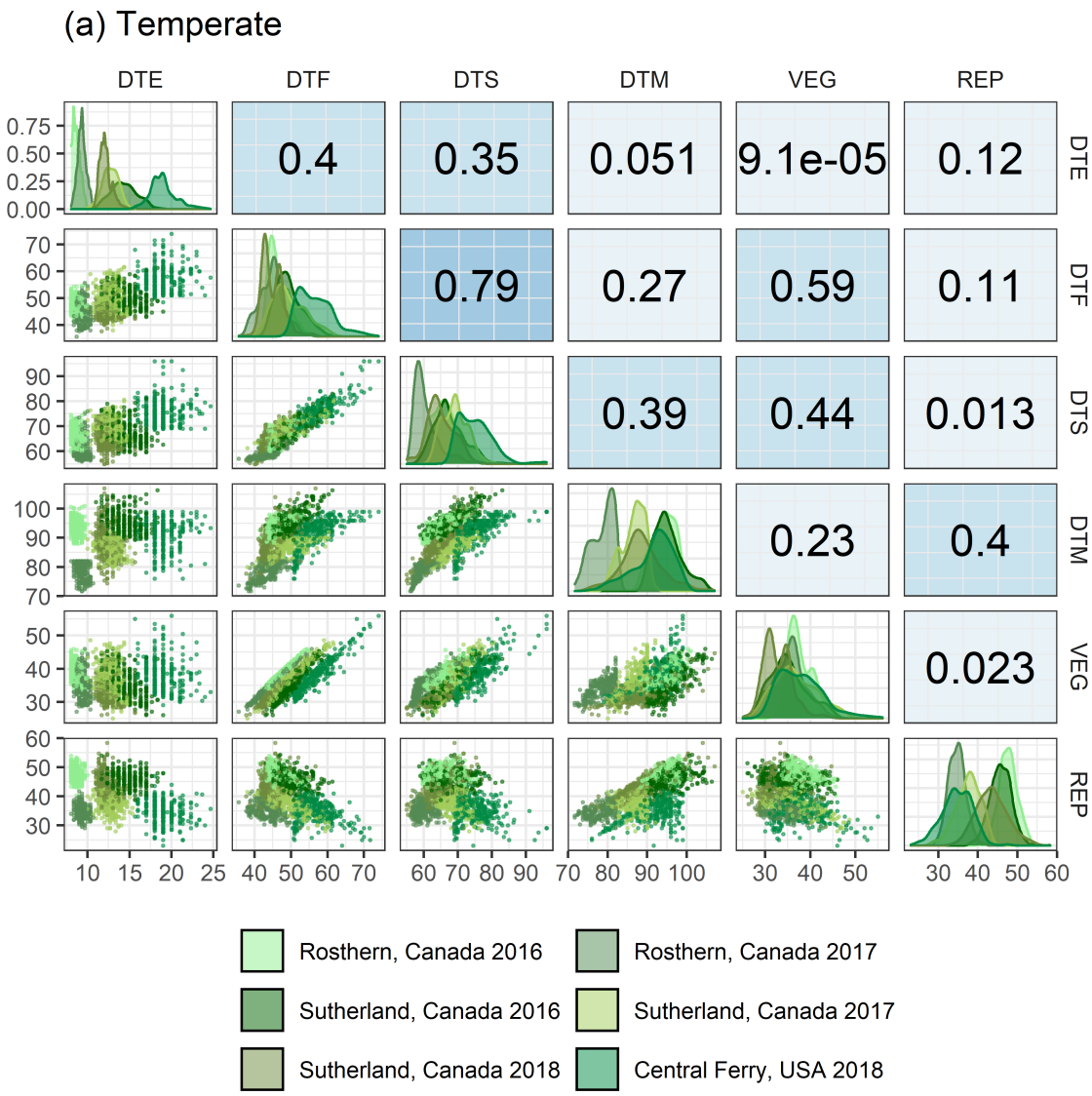


Phenology + EnvData



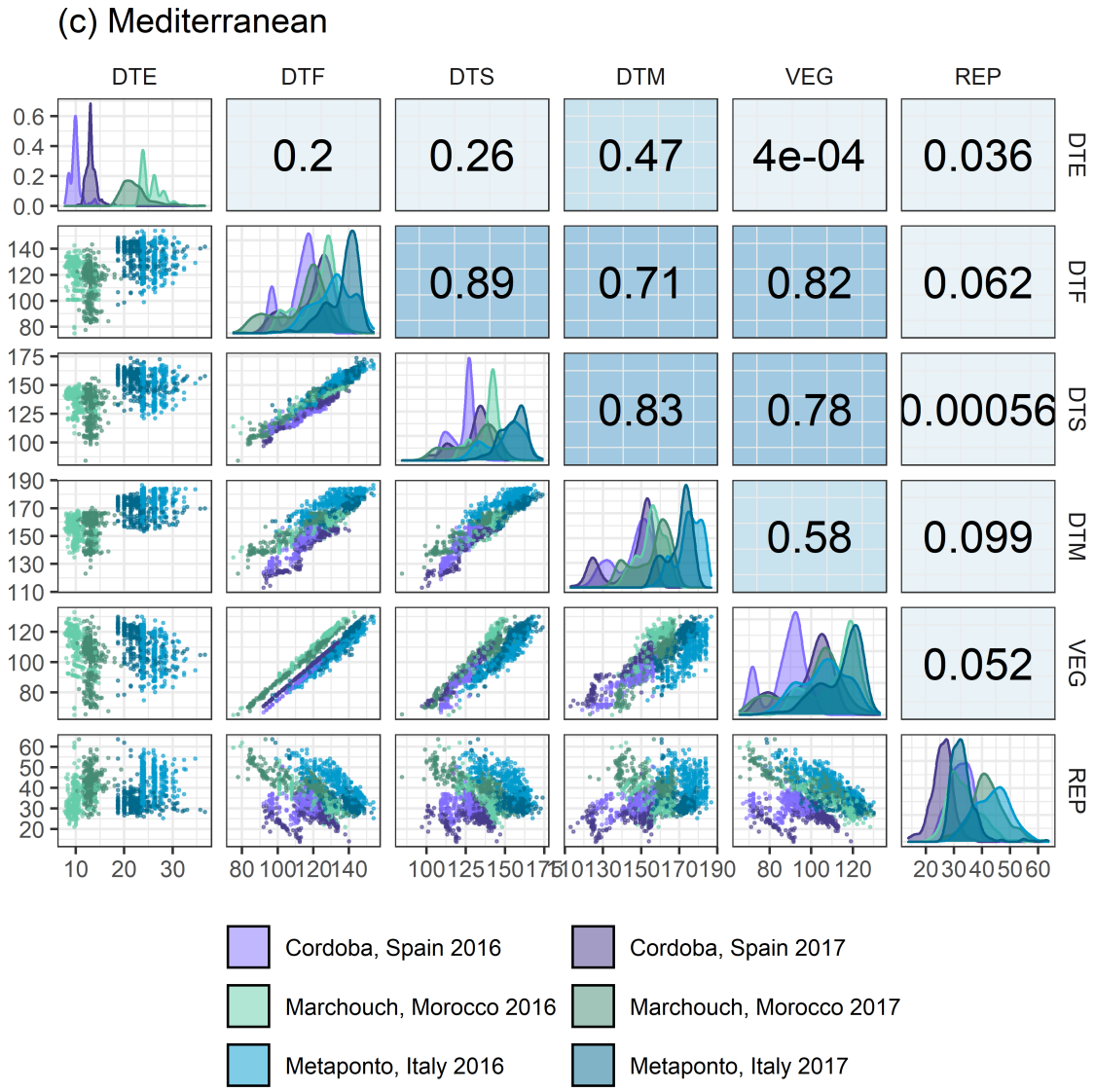

DTF
DTS
DTM
Bhopal, India 2016
Bhopal, India 2017
Jessore, Bangladesh 2016
Jessore, Bangladesh 2017
Bardiya, Nepal 2016
Bardiya, Nepal 2017
Cordoba, Spain 2016
Cordoba, Spain 2017
Marchouch, Morocco 2016
Marchouch, Morocco 2017
Metaponto, Italy 2016
Metaponto, Italy 2017
°Celcius
Hours
DaysAfterPlanting
Day length
Temperature

Correlations



(b) South Asia


DTE
DTF
DTS
DTM
VEG
REP
0.62
0.64
0.63
0.37
0.039
0.93
0.92
0.94
0.26
0.97
0.83
0.089
0.83
0.063
0.32
Bhopal, India 2016
Bhopal, India 2017
Jessore, Bangladesh 2016
Jessore, Bangladesh 2017
Bardiya, Nepal 2016
Bardiya, Nepal 2017



PCA Animation

Additional/Animation_PCA.gif

Phothermal Animation

Additional/Animation_3D.gif

PDFs

Entry Phenology

pdf_Phenology.pdf

Temperature and Photoperiod Regressions

pdf_TP.pdf

Model Predictions

pdf_Model.pdf

Photothermal Planes

pdf_3D.pdf
