SUPPLEMENTARY MATERIAL

Dynamic neural network modeling of thermal environments of two adjacent single-span greenhouses with different thermal curtain positions

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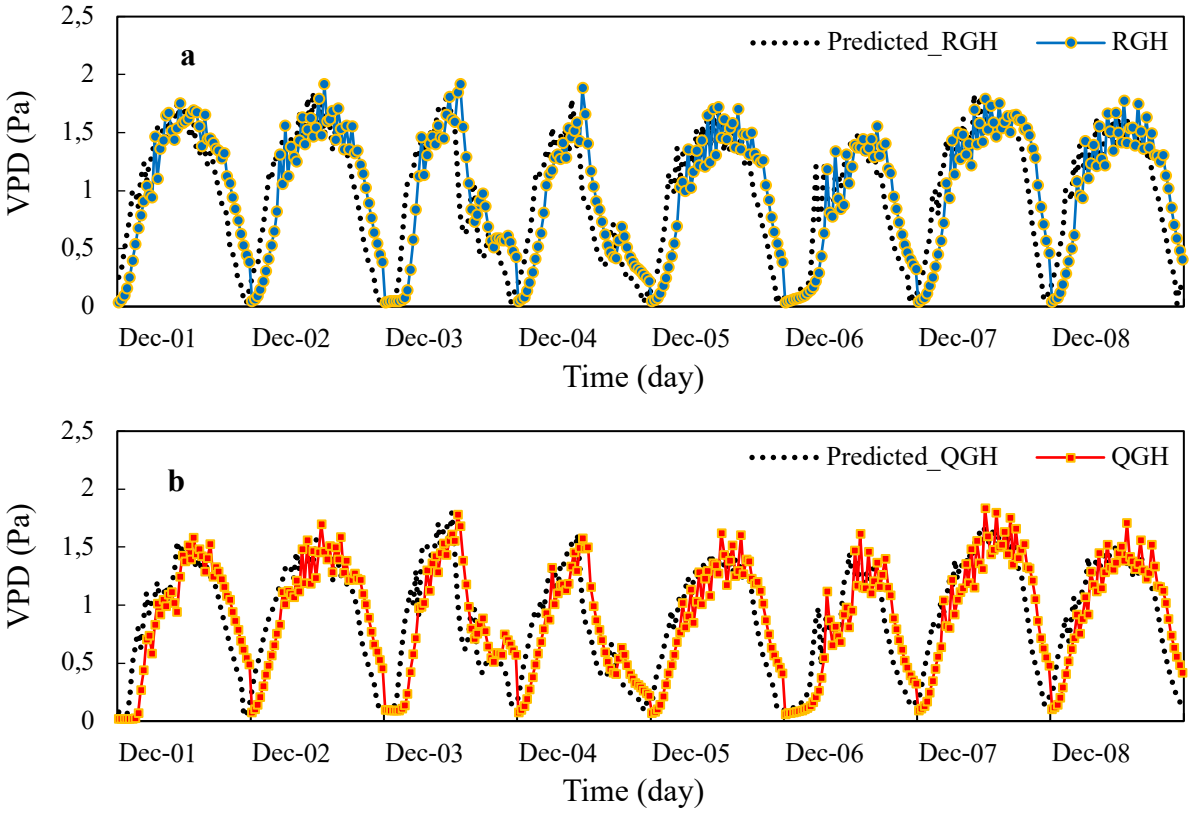

Figure S1. Predicted vapor pressure deficit in R greenhouse and Q greenhouse. RGH, R greenhouse; QGH, Q greenhouse; VDP, vapor pressure deficit.

Table S1. Descriptive statistics of microclimate parameters.

Parameter/statistical tool		Mean	Standard error	Standard deviation	Sample variance	Range	Minimum	Maximum
Temperature	R	20.01	0.06	4.78	22.86	34.03	2.05	36.08
	Q	19.31	0.06	4.83	23.37	34.5	1.42	35.92
	Outside	9.16	0.09	7.54	56.83	41.77	-9.8	31.97
RH	R	50.32	0.27	22.01	484.28	84.33	13.77	98.11
	Q	52.36	0.26	21.06	443.32	84.31	14.36	98.67
	Outside	42.57	0.21	17.16	294.52	82.56	13.1	95.65
VPD	R	1.23	0.01	0.86	0.74	4.21	0.02	4.23
	Q	1.21	0.01	0.77	0.59	4.08	0.02	4.1
SR	R	254.64	1.83	150.67	22702.21	784.7	3.74	786.2
	Q	205.33	1.55	127.64	16291.06	535.7	2.13	536.82
	Outside	377.27	2.07	195.72	48728.31	977.2	5.54	982.80
irT	R	18.75	0.19	16.01	256.31	62.74	1.75	53.99
	Q	22.77	0.08	6.97	48.63	44.37	2.36	46.73
irRH	R	53.15	0.4	32.58	1061.38	90.69	5.47	96.16
	Q	44.49	0.27	22.06	486.68	86.69	10.01	96.71
Yield	R	6.33	0.02	1.58	2.51	6.69	3.82	13.51
	Q	7.72	0.03	1.92	3.70	11.77	4.68	16.44

R, R greenhouse; Q, Q greenhouse; RH, relative humidity; VPD, vapor pressure deficit; SR, solar radiation; irT, indoor roof temperature; irRH, indoor roof relative humidity.

Table S2. Model architecture and accuracy parameter for R greenhouse.

Model	No. of hidden neurons: delays	Training: validation: testing	R^2, %			MSE			RMSE		
			Training	Validation	Testing	Training	Validation	Testing	Training	Validation	Testing
	10:02	70:15:15	97.6	97.2	96.8	9.66E-04	1.03E-04	1.24 E-04	3.11E-02	1.01E-02	1.11 E-02
T	10:03	70:15:15	97.6	97.1	97.3	9.20E-04	1.11E-04	1.07 E-04	3.03E-02	1.05E-02	1.03 E-02
	10:04	70:15:15	97.5	96.8	97.5	1.01E-04	1.17E-04	1.06 E-04	1.00E-02	1.08E-02	1.03 E-02
RH	10:02	70:15:15	97.2	97.8	97.6	3.77E-04	2.83E-04	3.37 E-04	1.94E-02	1.68E-02	1.84 E-02
	10:03	70:15:15	98.0	97.5	97.4	2.76E-04	3.24E-04	3.47 E-04	1.66E-02	1.80E-02	1.86 E-02
	10:04	70:15:15	98.1	97.4	97.3	2.31E-04	3.12E-04	3.95 E-04	1.52E-02	1.77E-02	1.99 E-02
	10:02	70:15:15	99.0	98.7	98.8	8.37E-04	1.12E-03	1.06 E-03	2.89E-02	3.35E-02	3.26 E-02
VPD	10:03	70:15:15	99.2	98.6	98.2	6.74E-04	1.14E-03	1.19 E-03	2.60E-02	3.38E-02	3.45 E-02
	10:04	70:15:15	99.1	98.7	98.6	7.60E-04	1.04E-03	1.13 E-03	2.76E-02	3.22E-02	3.36 E-02
Yield	10:02	70:15:15	99.9	99.9	99.9	4.27E-05	1.61E-05	1.91 E-05	6.53E-03	4.01E-03	4.37 E-03
	10:03	70:15:15	99.9	99.9	99.9	6.90E-05	8.13E-05	3.75 E-05	8.31E-03	9.02E-03	6.12 E-03
	10:04	70:15:15	99.9	99.9	99.9	5.83E-06	2.12E-05	1.20 E-05	2.41E-03	4.60E-03	3.46 E-03

R^2, coefficient of determination; MSE, mean square error; RMSE, root mean square error; RGH, R greenhouse; QGH, Q greenhouse; T, air temperature in °C; RH, relative humidity; VPD, vapor pressure deficit.

Table S3. Model architecture and accuracy parameter for Q greenhouse.

Model	No. of hidden neurons: delays	Training: validation: testing	R^2, %			MSE			RMSE		
			Training	Validation	Testing	Training	Validation	Testing	Training	Validation	Testing
	10:02	70:15:15	97.2	97	97.4	1.04E-03	1.18E-03	1.10E-03	3.22E-02	3.44E-02	3.32E-02
T	10:03	70:15:15	97.3	97	97.3	1.03E-03	1.16E-03	1.11E-03	3.21E-02	3.41E-02	3.33E-02
	10:04	70:15:15	97.3	96.7	97.3	1.02E-03	1.14E-03	1.11E-03	3.19E-02	3.38E-02	3.33E-02
RH	10:02	70:15:15	97.3	97.6	97.5	3.28E-03	2.86E-03	3.21E-03	5.73E-02	5.35E-02	5.67E-02
	10:03	70:15:15	97.9	96.9	96.9	2.62E-03	3.79E-03	3.77E-03	5.12E-02	6.16E-02	6.14E-02
	10:04	70:15:15	97.9	97.4	97	3.01E-03	3.01E-03	3.70E-03	5.49E-02	5.49E-02	6.08E-02
	10:02	70:15:15	98.9	98.9	98.9	7.29E-04	8.09E-04	8.03E-04	2.70E-02	2.84E-02	2.83E-02
VPD	10:03	70:15:15	98.8	98.8	98.5	8.19E-04	8.73E-04	1.09E-03	2.86E-02	2.95E-02	3.30E-02
	10:04	70:15:15	98.8	98.4	98.7	8.66E-04	1.03E-03	9.42E-04	2.94E-02	3.21E-02	3.07E-02
	10:02	70:15:15	99.9	99.9	99.9	4.56E-05	1.83E-05	2.69E-05	6.75E-03	4.28E-03	5.19E-03
Yield	10:03	70:15:15	99.9	99.9	99.9	1.07E-05	1.99E-04	1.74E-05	3.27E-03	1.41E-02	4.17E-03
	10:04	70:15:15	99.9	99.9	99.9	9.08E-06	2.01E-05	2.74E-04	3.01E-03	4.48E-03	1.66E-02

R^2, coefficient of determination; MSE, mean square error; RMSE, root mean square error; RGH, R greenhouse; QGH, Q greenhouse; T, air temperature in °C; RH, relative humidity; VPD, vapor pressure deficit.

Table S4. Analysis of variance of actual vs predicted data for R greenhouse and Q greenhouse.

	RGH				QGH			
	T	RH	VPD	Yield	T	RH	VPD	Yield
$F_{statistics}$	9.26e-05	1.68e-04	0.13	0.05	0.08	0.02	0.04	0.01
P-value	0.99	0.99	0.72	0.82	0.77	0.89	0.84	0.90
$F_{critical}$	3.84	3.84	3.84	3.84	3.84	3.84	3.84	3.84

RGH, R greenhouse; QGH, Q greenhouse; T, air temperature in °C; RH, relative humidity; VPD, vapor pressure deficit. T, RH, and VPD: numerator degrees of freedom (df1) =1; denominator degrees of freedom (df2) =13526; for yield: df1 =1; df2 =11034.

Table S5. Mean of parameters.

Parameter	RGH		QGH	
	Actual	Predicted	Actual	Predicted
Temperature, °C	20.01	20.01	19.31	19.29
RH, %	50.34	50.35	52.38	52.33
VPD, kPa	1.31	1.31	1.20	1.21
Yield, g	6.33	6.33	7.72	7.72

RGH, R greenhouse; QGH, Q greenhouse; RH, relative humidity; VPD, vapor pressure deficit.

Table S6. Frequency distribution of vapor pressure deficit in R greenhouse and Q greenhouse.

Description	VPD range	RGH		QGH	
		Actual (%)	Predicted (%)	Actual (%)	Predicted (%)
Optimal range	0.5-1.19	2490 (36.8)	2445 (36.1)	3045 (45)	3114 (46)
Outside optimal range	0.1-0.49/1.2-4.29	4274 (63.2)	4319 (63.9)	3719 (55)	3650 (54)

VPD, vapor pressure deficit; RGH, R greenhouse; QGH, Q greenhouse.