

Supplements

Title:

Ramularia leaf spot disease of barley is highly host genotype-dependent and suppressed by continuous drought stress in the field

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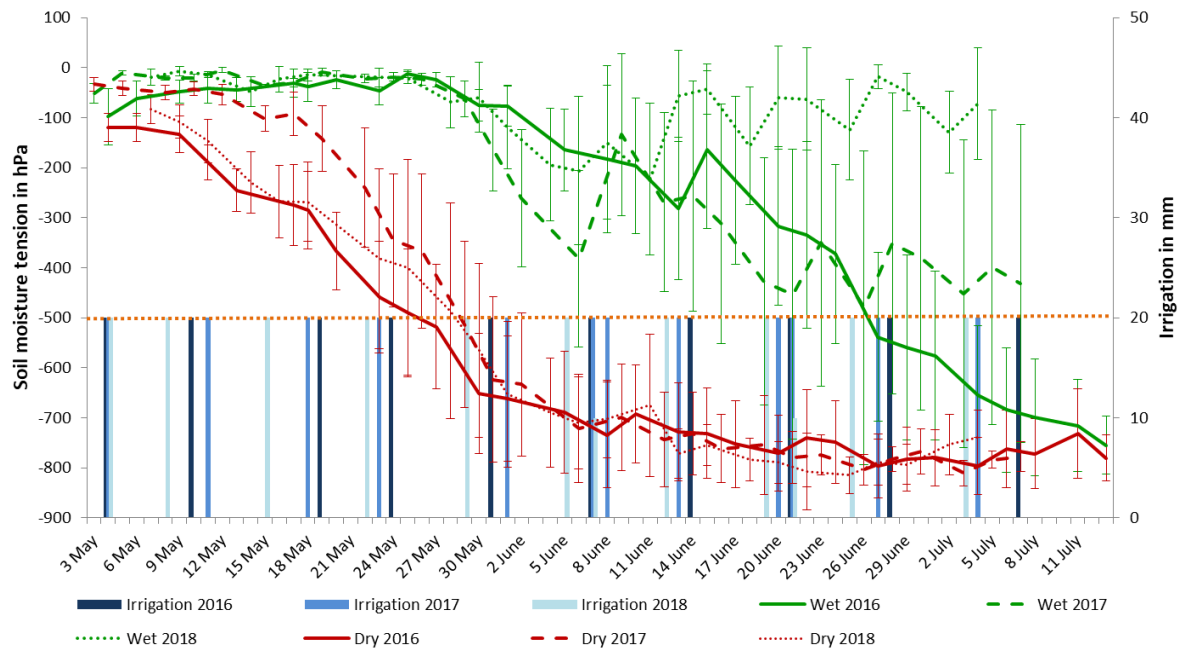
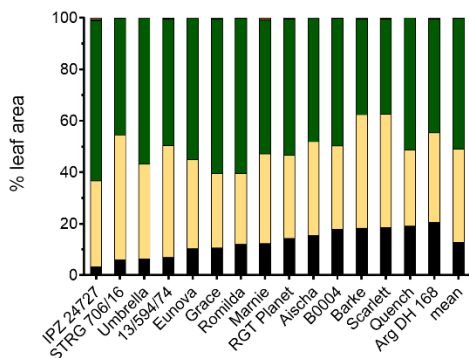


Figure S-1 Soil moisture tension in a depth of 45 cm in the rainout shelter experiment in a period between May and July in 2016 to 2018. Soil moisture is represented in hPa as mean of three technical replicates. Error bars show the standard error of the mean. Drought condition was set as soil moisture tension below -500 hPa. The weekly irrigation in the irrigated plots was 20 mm and is represented as blue bars.

A



B

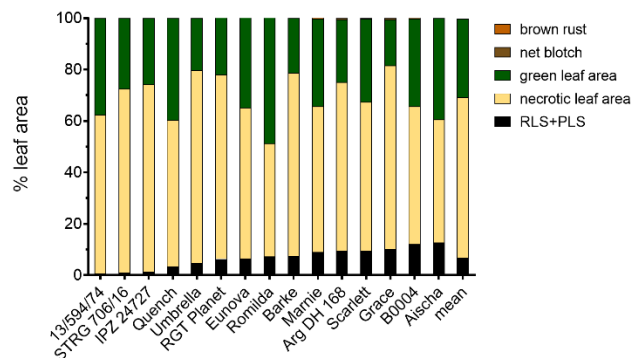


Figure S-2 Mean proportions of green leaf area, senescent leaf area and infestation of recorded foliar diseases (brown rust, *Ramularia* and physiological leaf spot, net blotch) on upper leaves (flag leaf, flag leaf -1) of 15 spring barley genotypes grown under irrigation [A] or under drought conditions [B] in the rainout shelter between 2016 and 2018. Visual assessment was conducted at growth stage 83 – 85.

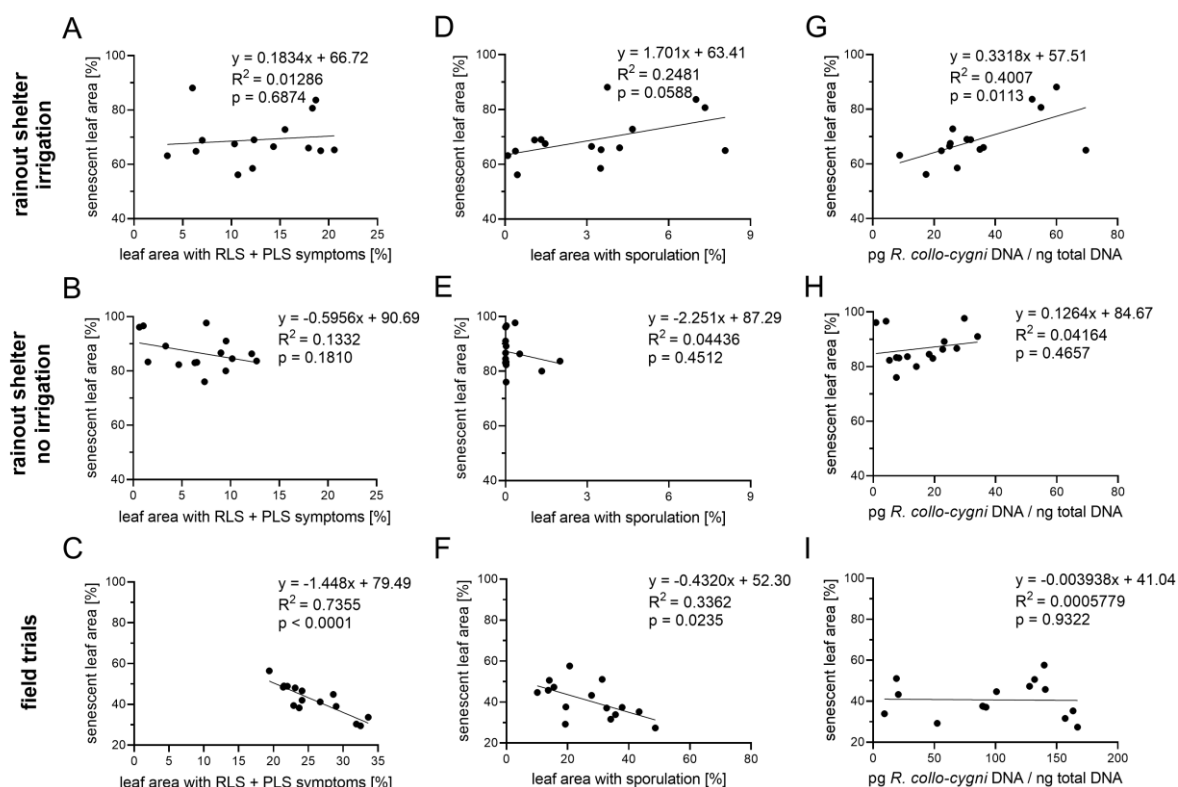


Figure S-3 Relations between assessed leaf senescence of flag leaf and flag leaf minus one (F-1) and Ramularia leaf spot disease in the rainout shelter between 2016 and 2018 and in the field trials between 2016 and 2019 for symptoms and between 2018 and 2019 for sporulation and DNA contents, respectively. Data points represent calculated means of 15 spring barley genotypes. Leaf senescence, symptoms of RLS and PLS and Ramularia-sporulation are presented as percentage of leaf area, respectively. Visual assessment of upper leaves was conducted at growth stage 83 – 85. Statistical analysis: linear regression; p value indicates significance of the slope from zero.

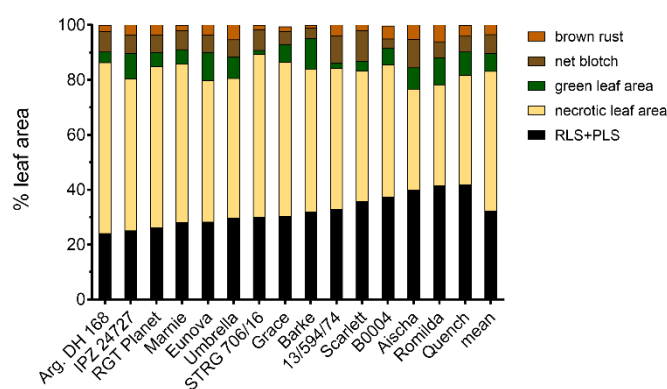


Figure S-4 Mean proportions of green leaf area, senescent leaf area and infestation of recorded foliar diseases (brown rust, Ramularia and physiological leaf spot, net blotch) on upper leaves (flag leaf, flag leaf -1) of 15 spring barley genotypes grown in the field trials between 2016 and 2019. Visual assessment was conducted at growth stage 83 – 85.

Table S-1 Agronomic data and RLS disease infestation of 59 spring barley genotypes tested in double rows (micro plots) under irrigation (control) and no irrigation in the rainout shelter in 2016 and 2017. The table demonstrates the mean date of heading [days from Jan 1st], mean number of ear carrying stalks, average of total grain weight per double row [g], mean thousand kernel weight (TKW) [g], the mean of the fraction of kernels with a size > 2.5 mm [%], mean leaf area with RLS and PLS symptoms [%], mean leaf area with sporulation [%] and mean Ramularia-DNA contents [pg/ng total DNA] of flag leaf (F) and flag leaf minus one (F-1).

genotype	ear type	heading date [days from Jan 1 st]		no. of ear carrying stalks		grain weight per double row [g]		TKW [g]		fraction of kernels > 2.5 mm [%]		leaf area with RLS + PLS [%]		leaf area with sporulation [%]		Ramularia-DNA [pg/ng total DNA]	
		irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation
12/667/25*	2-row	171.9	167.4	287.4	151.4	287.2	127.7	56.1	53.8	91.2	94.0	6.5	0.5	0.0	0.1	27.5	3.6
13/542/6*	2-row	167.9	164.9	297.9	163.4	284.9	172.7	55.7	55.2	93.4	91.7	13.5	1.0	3.0	0.0	87.3	5.5
13/554/34*	2-row	170.9	169.9	199.4	157.4	185.9	160.1	55.3	53.7	90.4	93.2	11.0	1.0	6.0	0.0	19.2	3.4
13/568/39*	2-row	167.9	163.9	265.9	172.9	327.8	175.6	64.9	59.2	95.0	92.6	13.5	1.0	2.0	0.0	55.2	2.5
13/594/74* [#]	2-row	167.9	164.4	264.4	168.9	279.6	175.2	61.8	58.7	93.4	94.1	13.0	1.0	1.6	0.0	50.1	1.8
Abessinische	6-row	161.3	159.5	209.8	98.5	145.5	111.8	51.3	49.4	77.4	57.7	17.3	16.3	0.8	0.0	15.0	8.7
Aischa [#]	2-row	169.3	165.8	243.8	167.2	227.2	162.4	59.5	55.7	97.9	96.6	21.5	19.0	5.5	3.0	34.6	16.1
Alava	6-row	164.0	163.5	135.8	103.5	208.7	152.5	58.0	56.3	79.0	73.2	25.0	18.3	6.8	1.3	49.2	30.6
Argentinische DH 168 [#]	2-row	166.3	162.8	296.8	180.7	229.4	152.9	57.2	58.3	93.8	95.1	30.5	14.0	4.8	2.0	46.3	19.3
Argentinische DH 22	2-row	165.5	164.8	329.8	165.0	226.4	118.7	54.9	55.3	90.9	88.9	22.8	6.5	5.8	0.0	67.5	8.9
Auriga	2-row	171.5	166.3	386.0	198.7	216.9	127.1	45.6	47.5	80.4	89.5	26.3	10.0	4.3	0.0	34.4	103.7
B0001	2-row	170.3	167.0	258.8	155.2	252.0	163.1	59.8	58.1	95.0	96.2	21.3	7.3	4.5	0.3	24.2	20.5
B0004 [#]	2-row	169.8	165.8	274.3	177.5	231.0	169.7	56.7	55.1	96.0	92.5	26.5	17.8	6.3	0.8	45.8	33.1
B3162	2-row	166.5	165.5	239.5	141.5	252.6	127.6	58.1	57.5	91.8	95.2	22.5	5.0	3.5	0.0	17.7	22.1
B3163	2-row	169.0	168.8	305.8	126.2	232.4	97.4	54.4	51.6	93.8	88.8	17.8	6.0	3.0	0.0	37.9	8.6
B3250	2-row	170.0	167.8	329.8	186.7	242.4	146.6	52.3	51.6	90.5	91.4	16.3	4.5	3.8	0.0	32.2	11.3
B3254	2-row	170.0	168.5	338.3	155.7	255.7	99.3	49.3	47.4	93.0	86.5	18.8	5.8	4.5	0.0	59.3	9.6
B3482	2-row	171.3	166.8	322.3	172.2	237.4	158.9	57.1	51.6	94.2	96.5	22.0	8.0	5.5	0.0	22.2	22.3
B3914	2-row	168.0	166.5	275.3	158.5	282.1	177.4	59.0	55.8	96.9	94.7	22.8	12.0	5.3	1.3	54.6	70.9

genotype	ear type	heading date [days from Jan 1 st]		no. of ear carrying stalks		grain weight per double row [g]		TKW [g]		fraction of kernels > 2.5 mm [%]		leaf area with RLS + PLS [%]		leaf area with sporulation [%]		Ramularia-DNA [pg/ng total DNA]	
		irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation
B4032	2-row	166.3	161.8	302.5	205.0	272.4	181.3	53.9	53.7	93.8	95.3	26.3	14.5	5.8	0.3	52.8	83.8
B4403	2-row	168.5	165.5	273.8	170.5	262.3	140.2	55.0	54.6	92.5	87.4	15.3	10.3	4.8	0.0	51.1	29.6
Barke [#]	2-row	170.0	166.0	292.8	174.5	250.8	177.6	56.2	56.4	95.9	96.4	24.5	11.0	9.0	0.5	74.2	44.3
Baronesse	2-row	169.3	165.8	293.3	201.2	280.7	171.6	58.1	51.7	95.7	94.4	19.3	1.5	3.3	0.0	47.7	4.0
BRS 195	2-row	169.8	166.0	297.8	151.2	219.1	141.2	54.9	53.2	90.9	95.5	11.0	13.5	1.0	1.5	18.9	68.4
CDC McGwire	2-row	171.5	169.0	288.8	149.5	283.7	98.0	44.5	44.0	67.7	53.3	17.5	3.8	3.0	0.5	35.7	6.0
Emperor	2-row	165.5	164.5	276.0	152.7	202.0	107.6	50.4	46.1	70.7	64.3	20.3	14.0	9.3	1.8	55.3	45.0
Endora	2-row	167.8	165.5	329.3	187.7	285.2	166.4	55.3	52.2	96.2	92.3	29.5	12.0	6.3	1.8	67.4	32.9
Engledow India	6-row	156.0	153.8	191.0	129.2	118.6	79.1	41.9	40.6	42.9	42.1	24.5	14.5	3.3	0.3	17.3	17.5
Eunova [#]	2-row	167.0	165.5	266.3	141.2	254.1	152.0	57.0	55.9	95.1	92.7	14.3	9.8	1.6	0.0	29.1	12.5
Flagship	2-row	157.0	156.5	289.0	180.7	156.5	91.7	58.5	57.9	92.0	88.6	27.3	17.5	3.0	0.0	17.5	18.9
Foster	6-row	161.8	160.0	142.8	93.7	253.7	168.1	47.9	46.8	93.6	88.5	11.8	14.3	1.0	0.8	23.0	51.1
Grace [#]	2-row	169.5	164.8	261.8	169.2	258.4	172.9	57.3	55.0	94.2	92.0	15.0	14.0	0.5	0.0	17.8	27.1
IPZ 24727 [#]	2-row	172.3	168.5	280.8	143.2	234.6	122.4	55.6	53.0	93.5	94.7	4.3	2.0	0.0	0.0	10.4	11.3
Iron	2-row	171.0	169.0	234.3	155.5	218.1	159.2	51.6	53.1	94.8	94.7	10.5	12.3	0.4	0.0	15.7	10.4
Jerusalemmer	2-row	173.3	171.8	221.8	110.0	216.7	92.0	55.5	51.2	89.3	89.7	17.5	13.0	1.0	0.0	23.8	32.1
Lenka	2-row	169.3	166.8	272.3	127.0	287.5	125.4	56.4	53.0	95.6	96.7	11.5	14.8	0.8	0.0	11.9	36.1
Lotos	2-row	172.0	167.3	278.0	122.7	201.2	94.7	53.8	48.7	76.9	62.4	15.8	12.5	3.3	1.0	32.3	35.9
Marnie [#]	2-row	170.0	165.5	269.3	149.5	280.0	154.6	57.2	56.5	97.1	97.3	17.3	13.3	1.0	0.0	32.7	39.9
Marthe	2-row	169.0	165.8	293.8	173.0	240.5	157.7	53.2	53.0	95.5	96.2	18.3	10.3	2.5	0.0	24.0	1.9
Morex	6-row	163.8	160.3	132.5	86.0	208.0	145.4	46.7	44.2	91.3	84.7	11.5	18.8	2.0	0.0	28.6	34.5
Palmella Blue	2-row	158.3	156.0	252.5	155.0	83.3	65.8	62.8	60.5	86.6	89.9	22.5	11.8	2.0	0.1	8.5	11.5

genotype	ear type	heading date [days from Jan 1 st]		no. of ear carrying stalks		grain weight per double row [g]		TKW [g]		fraction of kernels > 2.5 mm [%]		leaf area with RLS + PLS [%]		leaf area with sporulation [%]		Ramularia-DNA [pg/ng total DNA]	
		irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation	irrigation	no irrigation
Propino	2-row	169.5	166.3	293.8	148.0	260.5	187.1	61.5	58.2	96.2	96.7	20.3	8.5	4.8	0.0	37.7	19.3
Quench [#]	2-row	171.0	166.5	265.3	167.0	250.8	150.8	56.1	53.8	94.0	93.4	28.3	4.8	5.5	0.0	42.6	34.8
RGT Planet [#]	2-row	167.5	164.3	319.3	180.2	329.4	201.6	60.7	58.0	96.2	95.1	19.5	9.0	4.8	0.0	36.4	29.0
Romilda [#]	2-row	171.5	167.5	244.0	152.5	208.6	155.4	59.0	56.7	95.4	92.0	17.5	11.0	5.3	0.0	38.8	10.6
Scarlett [#]	2-row	167.8	165.8	277.0	161.2	269.5	148.3	54.6	52.9	97.1	94.9	26.8	14.3	6.0	0.0	53.3	50.8
SHAKIRA	2-row	167.5	165.0	251.3	151.5	220.7	150.2	61.1	59.5	97.6	98.6	23.3	10.3	3.5	0.0	37.3	12.9
Steptoe	2-row	161.5	160.3	159.8	95.7	230.0	148.3	56.8	54.2	92.7	92.3	31.3	28.3	5.0	2.3	18.4	40.1
Streif	2-row	171.5	167.8	290.0	165.2	287.1	170.1	56.9	54.5	94.4	95.9	20.5	22.5	1.5	0.3	34.6	65.1
STRG 606/12	2-row	167.9	166.4	243.9	136.9	251.5	144.0	57.1	53.6	94.6	92.1	8.0	0.5	1.6	0.0	35.3	1.5
DILIGENCE	2-row	170.9	162.4	257.4	174.9	210.6	194.4	56.9	57.0	89.2	93.8	9.5	1.5	2.5	0.0	19.7	3.0
STRG 654/14*	2-row	172.9	166.4	256.9	177.9	264.0	196.9	59.4	56.0	91.5	91.8	11.5	1.0	2.0	0.0	28.9	4.6
STRG 689/12A*	2-row	167.9	167.9	315.9	149.9	317.5	150.2	62.1	59.8	95.0	95.4	10.5	4.0	3.0	0.0	21.5	0.5
STRG 690/16*	2-row	167.9	167.9	209.9	123.4	185.8	111.0	60.8	57.1	94.7	92.7	5.5	1.5	2.1	0.0	28.1	0.9
STRG 695/16*	2-row	167.9	167.9	209.9	123.4	185.8	111.0	60.8	57.1	94.7	92.7	5.5	1.5	2.1	0.0	28.1	0.9
STRG 706/16* [#]	2-row	167.9	164.4	288.9	256.9	223.8	265.5	55.9	59.4	93.4	96.7	7.0	2.0	5.0	0.1	62.5	7.9
SYDNEY	2-row	165.0	162.3	330.3	178.2	246.4	125.1	57.6	55.8	91.6	88.1	21.5	9.5	5.8	2.0	49.6	15.7
Umbrella [#]	2-row	170.8	166.3	324.3	162.0	287.7	130.5	51.9	52.3	94.7	95.7	9.5	7.0	0.6	0.0	22.8	7.9
Ven	6-row	165.3	164.3	169.5	101.7	256.9	136.9	43.9	44.2	63.3	54.0	18.3	9.0	2.8	0.0	43.7	36.3
Ventina	2-row	167.5	165.0	385.3	212.2	340.1	210.0	53.7	49.2	96.8	91.9	20.5	8.5	6.5	0.0	64.2	30.0
minimum		156.0	153.8	132.5	86.0	83.3	65.8	41.9	40.6	42.9	42.1	4.3	0.5	0.0	0.0	8.5	0.5
maximum		173.3	171.8	386.0	256.9	340.1	265.5	64.9	60.5	97.9	98.6	31.3	28.3	9.3	3.0	87.3	103.7
total mean		168.0	165.1	269.2	156.4	242.6	147.7	55.5	53.6	90.6	89.0	18.0	9.6	3.5	0.4	36.5	24.2

* genotype only tested in 2017

[#] assortment of 15 candidate genotypes tested in the rainout shelter

Table S-2 Dates of sowing, growth stages, harvest and number of tested genotypes in field trials and in the rainout shelter experiment in seasons between 2016 and 2019.

	field trial				rainout shelter		
	2016	2017	2018	2019	2016	2017	2018
	microplots	microplots	field plots	field plots	microplots	microplots	field plots
number of tested genotypes	59	59	59	15	59	59	15
3rd week of March		sowing		sowing			
4th week of March						sowing	
1st week of April					sowing		
2nd week of April			sowing				sowing
3rd week of April	sowing						
4th week of April							
1st week of May				GS 49			
2nd week of May							
3rd week of May							
4th week of May							
1st week of June		GS 32	GS 55-59		GS 51	GS 51	
2nd week of June	GS 32			GS 51-55			
3rd week of June	GS 37		GS 73-83	GS 63-67			
4th week of June							GS 73-83
1st week of July	GS 49-71		GS 85-87	GS 85-87			
2nd week of July							GS 85-90
3rd week of July					harvest	GS 90	
4th week of July						harvest	
1st week of August							
2nd week of August		GS 90					
3rd week of August	GS 90						

Table S-3 Recorded mean temperature in two meters above ground during field seasons between 2016 and 2019 and calculated means for each month between March and July. Mean temperatures between 1961 and 1990 are listed as baseline. The data was collected by a weather station at the location in Freising. The data was accessed from agro-meteorology web portal of the Bavarian State Institute for Agriculture (Agrarmeteorologie Bayern, 2020).

	average temperature [°C]					
	2016	2017	2018	2019	average (2016 - 2019)	average (1961 - 1990)
March	3.9	6.9	3.0	6.3	5.0	3.0
April	8.2	7.4	13.1	10.2	9.7	7.3
May	12.8	13.9	16.4	10.6	13.4	11.9
June	16.5	18.5	17.8	19.5	18.1	15.0
July	18.7	18.7	19.2	19.0	18.9	16.7
average (March - July)	12.0	13.1	13.9	13.1	13.0	10.8

Table S-4 Recorded sum of precipitation during the growth period during field seasons between 2016 and 2019 and calculated means for each month between March and July. The mean sums of precipitation between 1961 and 1990 are listed as baseline. The data was collected one meter above ground by a weather station at the location in Freising. The data was accessed from agro-meteorology web portal of the Bavarian State Institute for Agriculture (Agrarmeteorologie Bayern, 2020).

	sum of precipitation [mm]					
	2016	2017	2018	2019	average (2016 - 2019)	average (1961 - 1990)
March	41.4	42.6	30.1	48.5	40.7	43.4
April	48.8	82.1	10.3	12.3	38.4	55.5
May	98.1	68.6	91.4	118.0	94.0	89.6
June	105.5	56.3	123.0	79.3	91.4	103.7
July	93.1	115.8	69.1	54.3	83.1	98.3
average (March - July)	77.4	73.1	65.1	62.5	69.5	78.1

Table S-5 Recorded mean percentage of leaf wetness during the growth period during field seasons between 2016 and 2019 and calculated means for each month between March and July. The means of leaf wetness between 1995* and 2015 are listed as baseline. The data was collected by a weather station at the location in Freising. The data was accessed from agro-meteorology web portal of the Bavarian State Institute for Agriculture (Agrarmeteorologie Bayern, 2020).

	average leaf wetness [%]					
	2016	2017	2018	2019	average (2016 - 2019)	average (1995* - 2015)
March	11.6	31.6	59.5	36.5	34.8	25.4
April	28.1	35.0	42.6	21.4	31.8	24.8
May	27.6	36.4	45.5	47.9	39.4	27.1
June	35.6	33.0	53.7	40.0	40.6	29.8
July	38.4	38.5	43.4	44.1	41.1	31.0
average (March - July)	28.3	34.9	48.9	38.0	37.5	27.6

*data of leaf wetness is available since 1994.

Table S-6 Recorded average sum of global radiation during the growth period during field seasons between 2016 and 2019 and calculated means for each month between March and July. The mean sums of global radiation between 1995* and 2015 are listed as baseline. The data was collected in two meters above ground by a weather station at the location in Freising. The data was accessed from agro-meteorology web portal of the Bavarian State Institute for Agriculture (Agrarmeteorologie Bayern, 2020).

	average sum of global radiation [Wh/m ²]					
	2016	2017	2018	2019	average (2016 - 2019)	average (1995* - 2015)
March	2841	3203	2781	3170	2999	2951
April	4103	3800	5279	4842	4506	4361
May	4926	5842	5733	4492	5248	5251
June	5363	6564	5836	6851	6153	5812
July	5561	5476	6196	5745	5744	5534
average (March - July)	4559	4977	5165	5020	4930	4782

*data of leaf wetness is available since 1994.