

Table S1. Summary of locations and genotypes tested within California. All temperatures and water levels correspond to the entire fall growing season (Nov-June). Irrigation and precipitation levels are in mm.

Year	Location	Latitude	Longitude	Planting Date mm/dd/yyyy	Minimum Temp (°C)	Maximum Temp (°C)	Avg Temp (°C)	Total Irrigation	Total Precipitation	Total water	Genotype	Fertilizer applied (kg/ha)
2016-17	Davis	38.53	-121.77	11/15/2016 (Nelsen & Lundy, 2020)	7.88	19.98	13.93	0	835.7	835.7	UC Tahoe	57.4, 75.3, 82.1, 82.2
2017-18	Davis	38.54	-121.78	11/21/2017	7.19	21.26	14.23	190.5	315	505.5	LCS Odyssey	112
											AAC Synergy	
											UC Tahoe	
											UC Capay	
											OSU Full Pint	
											LCS Genie	
											UC Butta 12	
											CDC Copeland	
											UC B9K94	
											Klages	
2018-19	Davis	38.53	-121.77	12/13/2018	8.09	20.71	14.4	63.5	741.7	805.2	LCS Odyssey	101
											UC Tahoe	
											LCS Genie	
											UC Butta 12	
											UC B9K94	
											UC 1911	
											OSU Full Pint	
											CDC Copeland	

											UC Capay	
											AAC Synergy	
											Klages	
2020-21	Davis	38.53	-121.77	12/11/2020 (Nelsen & Lundy, 2020)	6.79	21.37	14.08	0	160	160	UC Tahoe	67
											LCS Genie	
											UC Capay	
											AAC Synergy	
											CDC Copeland	
											LCS Odyssey	
											UC 1412	
											UC 1911	
2016-17	Rio Vista	38.14	-121.74	11/16/2016 (Nelsen & Lundy, 2020)	5.98	19.26	12.62	0	594.4	594.4	UC Tahoe	27.4, 57.4, 78.8, 109.5, 109.6
2016-17	Tulelake	41.96	-121.47	05/05/2017 (Nelsen & Lundy, 2020)	6.68	26.59	16.64	290	287.1	577.1	UC Tahoe	27.4, 54.8, 57.4, 75.3, 82.1, 150.6
											UC Capay	0, 60, 90, 120
2020-21	Yolo Region site 2	38.8	-122.05	12/10/2020 (Nelsen & Lundy, 2020)	7.7	23.78	15.74	0	152.4	152.4	UC Tahoe	56
											LCS Genie	
											UC Capay	
											AAC Synergy	
											CDC Copeland	
											LCS Odyssey	
											UC 1412	
											UC 1911	
2017-18	Fresno	36.34	-120.11	11/29/2017	6.35	22.65	14.5	151.6	106.7	258.3	UC Capay	56
											OSU Full Pint	

											UC Capay	
											AAC Synergy	
											CDC Copeland	
											LCS Odyssey	
											UC 1412	
											UC 1911	
2017-18	Tehama	39.88	-122.36	12/15/2017	6.87	21.5	14.19	0	299.7	299.7	UC B9K94	125
											UC Butta 12	
											AAC Synergy	
											UC Capay	
											LCS Odyssey	
											LCS Genie	
											CDC Copeland	
											OSU Full Pint	
											UC Tahoe	
2018-19	Yolo Region site 3	38.8	-122.05	11/27/2018	8.98	20.45	14.72	0	739.2	739.2	UC Tahoe	107
											LCS Odyssey	
											UC Butta 12	
											OSU Full Pint	
											CDC Copeland	
											Klages	
											AAC Synergy	
											LCS Genie	
											UC Capay	
2017-18	Solano	38.15	-121.82	11/21/2017	3.88	18.85	11.37	0	322.6	322.6	LCS Odyssey	56

Table S2. Average productivity and quality traits by year, location and genotype. All GTs are in °C. * represents a significant difference from reference slope (p<0.05).

	Yield (kg ha⁻¹)	Yield stability (FW slope)	GPC (%)	GPC stability (FW slope)	Individ ual- grain weight (mg)	Plump (>2.78 mm) %	Onset GT	Peak GT	Offset GT	Differen ce between onset and peak GT	Differen ce between peak and offset GT
Year											
2016-17	5420		12.1		49	62	58.2	62.9	67.4	4.7	4.5
2017-18	4501		12.2		43	40	57.7	63.3	69.0	5.7	5.7
2018-19	5213		10.1		42	59	58.0	63.5	69.0	5.5	5.5
2020-21	3254		11.3		45	25	59.3	64.4	68.5	5.1	4.0
Location											
Davis	4942		11.5		44	47	57.8	63.2	68.2	5.4	5.0
Fresno	5419		11.3		45	53	58.5	63.6	69.2	5.1	5.6
Imperial Valley	3581		7.9		41	31	59.7	64.8	68.4	5.1	3.6
Merced	5387		11.4		36	54	57.3	62.7	68.2	5.4	5.6
Rio Vista	3160		12.6		41	51	57.3	62.2	67.1	4.9	4.9

Solano	2345		11.3		38	52	57.6	63.1	69.0	5.4	5.9
Tehama	3223		12.6		47	32	58.4	64.5	69.4	6.1	4.8
Tulelake Basin	7178		12.3		55	65	59.0	63.8	68.0	4.7	4.2
Yolo Region 2	2700		13.2		47	4	59.3	64.4	68.9	5.1	4.5
Yolo Region 3	3522		8.4		43	44	58.3	64.0	69.1	5.8	5.1
Genotype											
AAC Synergy	4065	0.94	10.8	0.90	41	48	57.6	63.3	68.6	5.7	5.4
CDC Copeland	3850	0.90	11.2	0.92	42	37	58.4	63.7	68.9	5.3	5.2
Klages	4294	0.54	11.6	1.10	46	38	57.7	63.1	68.8	5.4	5.7
LCS Genie	4676	1.03	11.8	1.03	45	35	59.1	64.4	69.2	5.3	4.8
LCS Odyssey	4968	1.28*	10.8	1.27	41	39	59.9	65.5	70.0	5.6	4.5
OSU Full Pint	5416	1.12	11.7	0.90	42	44	56.9	62.1	67.8	5.2	5.7
UC 1412	3285	1.20	11.2	1.33	49	9	59.6	64.6	68.4	5.1	3.8
UC 1911	3839	0.91	10.7	0.93	42	44	59.3	64.6	68.8	5.3	4.2

UC B9K94	4687	0.71	11.8	0.85	43	37	57.1	63.2	69.0	6.0	5.8
UC Butta 12	4714	0.94	11.6	0.78	44	78	57.8	63.8	69.8	6.0	6.0
UC Capay	4887	1.08	11.6	1.00	50	61	58.2	63.2	67.6	4.9	4.5
UC Tahoe	4864	1.09	11.5	0.82	44	49	57.9	62.9	67.9	5.0	5.0

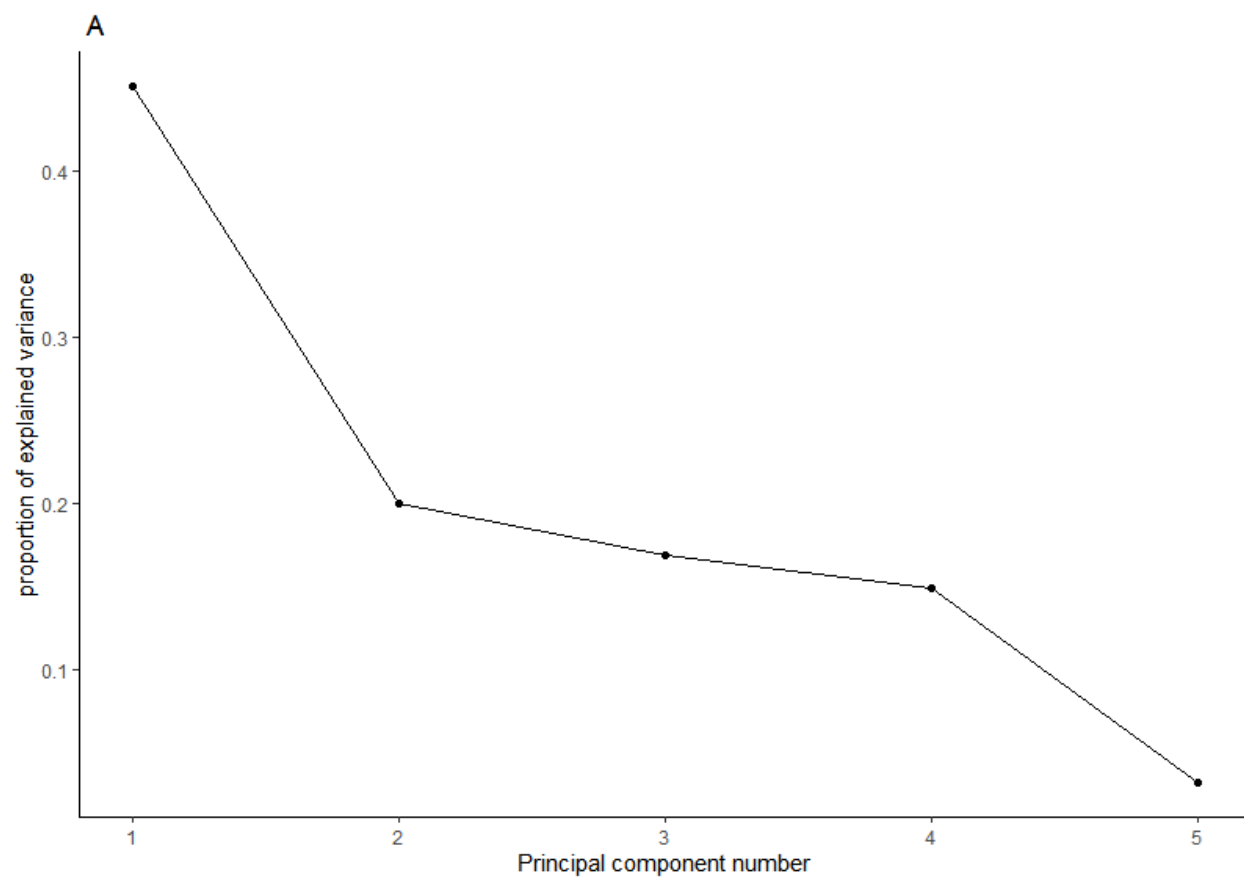
Table S3. Irrigation and precipitation levels pre and post heading for all sites in seasons 17-18, 18-19 and 20-21. All water values are in mm.

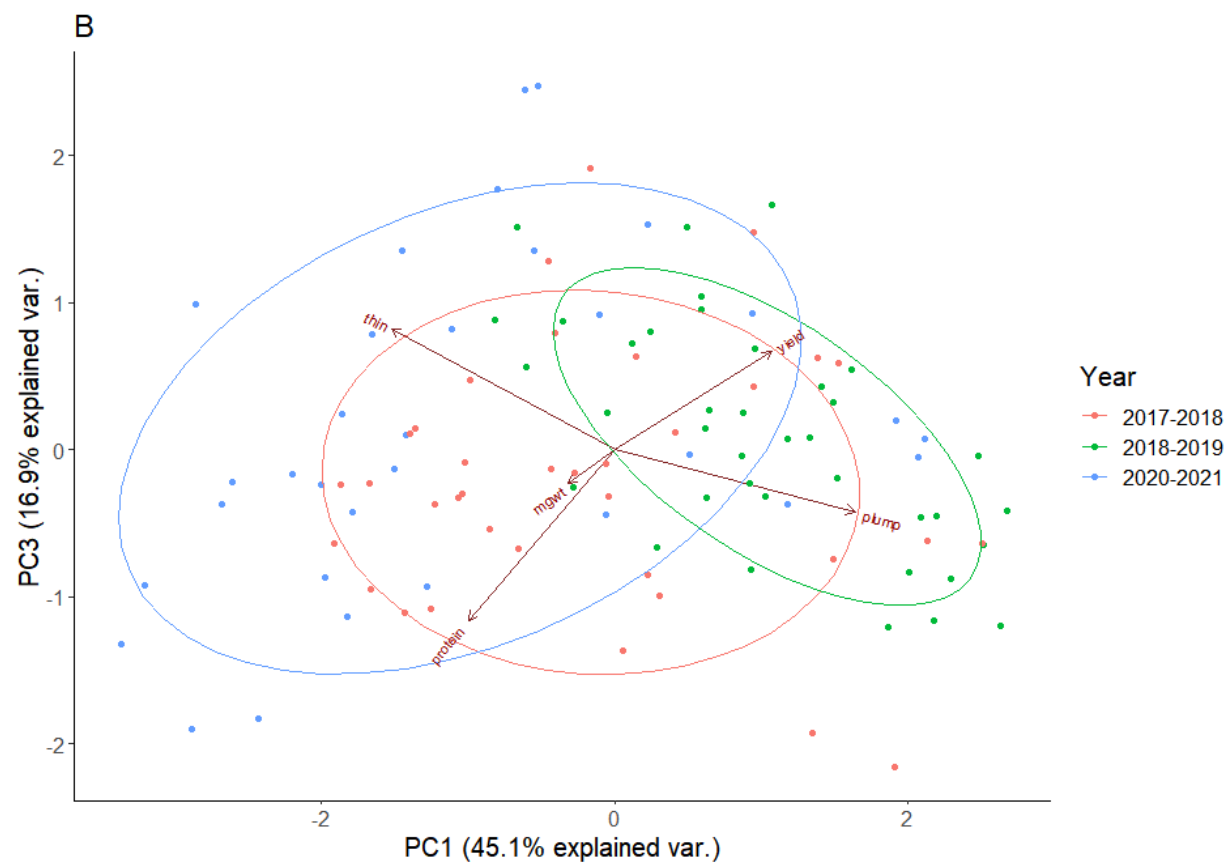
Year	Location	Irrigation pre-heading (11/1 to 3/14)	Irrigation post-heading (3/15 to 6/30)	Total Irrigation	Precipitation pre-heading (11/1 to 3/14)	Precipitation post-heading (3/15 to 6/30)	Total Precipitation	Water pre-heading (11/1 to 3/14)	Water post-heading (3/15 to 6/30)	Total water
2017-18	Davis	190.5	0	190.5	208.3	106.7	315	398.8	106.7	505.5
2017-18	Fresno	151.6	0	151.6	55.9	50.8	106.7	207.5	50.8	258.3
2017-18	Solano	0	0	0	208.3	114.3	322.6	208.3	114.3	322.6
2017-18	Tehama	0	0	0	165.1	134.6	299.7	165.1	134.6	299.7
2018-19	Davis	63.5	0	63.5	589.3	152.4	741.7	652.8	152.4	805.2
2018-19	Fresno	264.2	106.6	370.8	200.7	53.3	254	464.9	159.9	624.8
2018-19	Yolo Region site 3	0	0	0	619.8	119.4	739.2	619.8	119.4	739.2
2018-19	Merced	177.8	0	177.8	246.4	53.3	299.7	424.2	53.3	477.5
2020-21	Davis	0	0	0	147.3	12.7	160	147.3	12.7	160
2020-21	Fresno	88.9	50.8	139.7	101.6	15.2	116.8	190.5	66	256.5

2020-21	Yolo Region site 2	0	0	0	137.2	15.2	152.4	137.2	15.2	152.4
2020-21	Imperial Valley	221	221	442	27.9	0	27.9	248.9	221	469.9



Figure S1. Map of test locations in California.





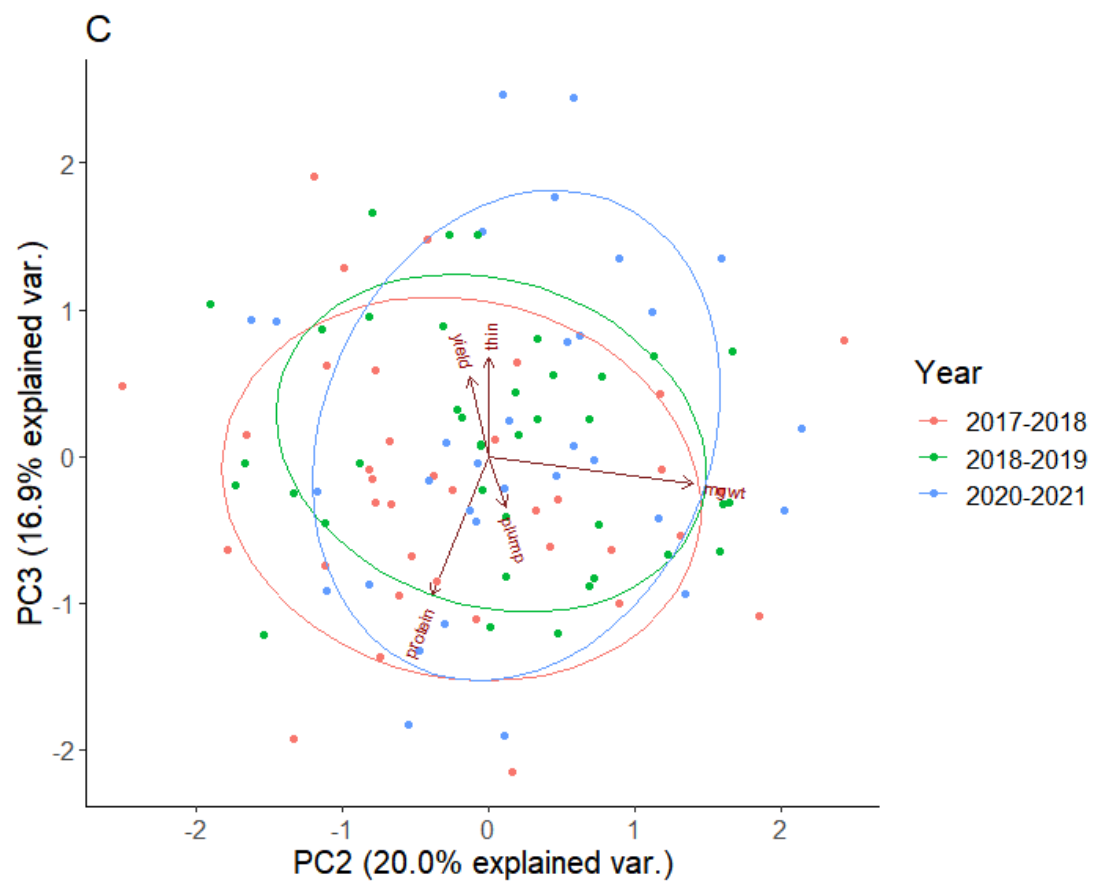
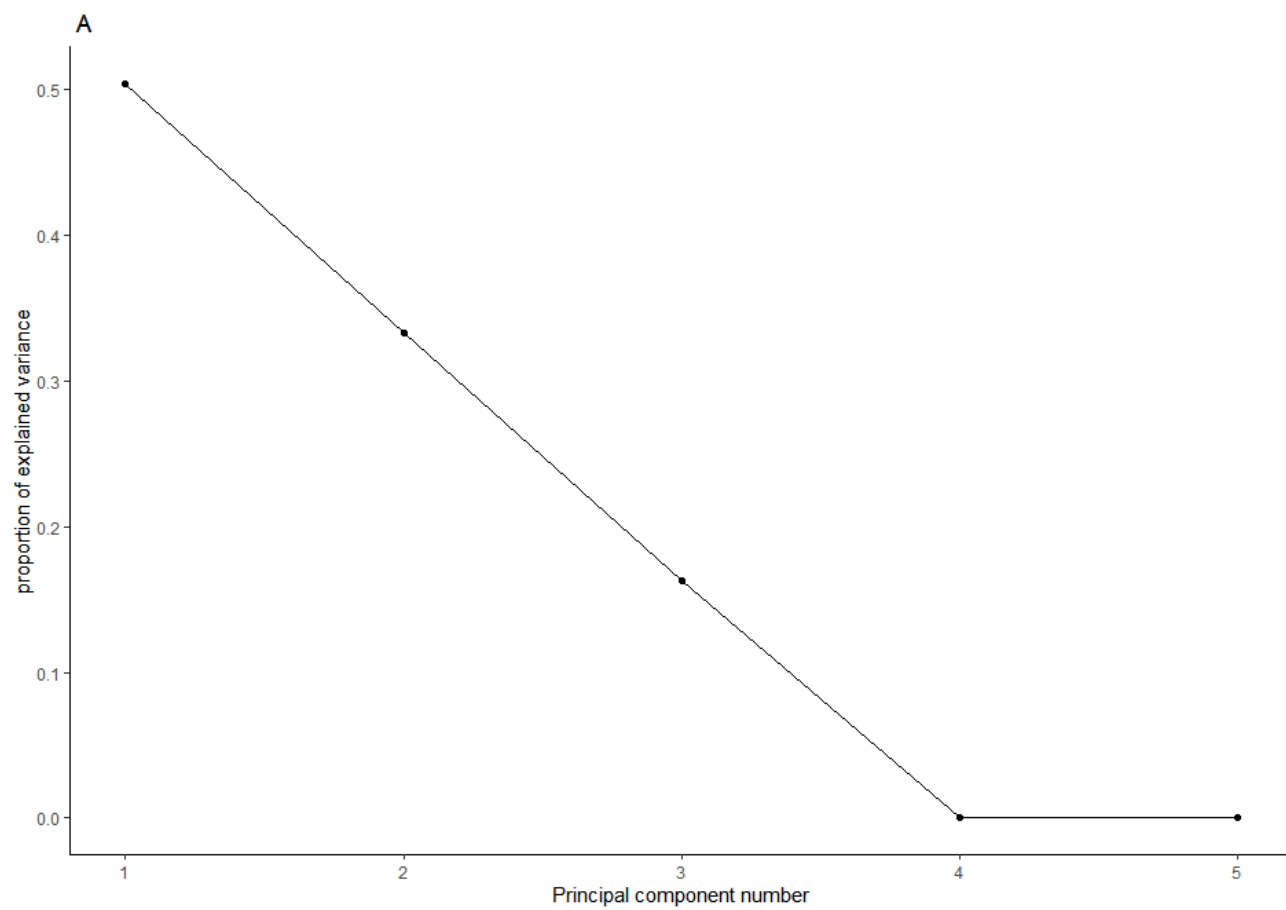
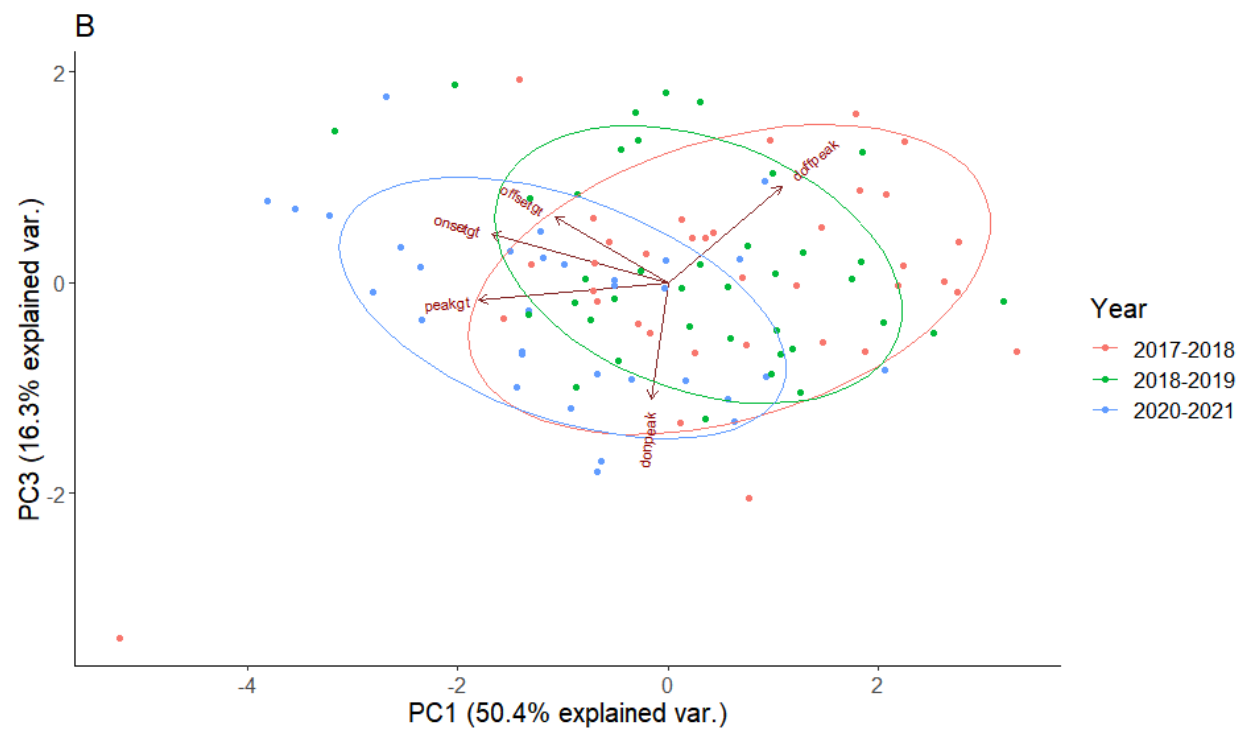


Figure S2. Year based biplots of productivity and quality traits A) PCA scree plot; PCs B) 1 and 3; C) 2 and 3.





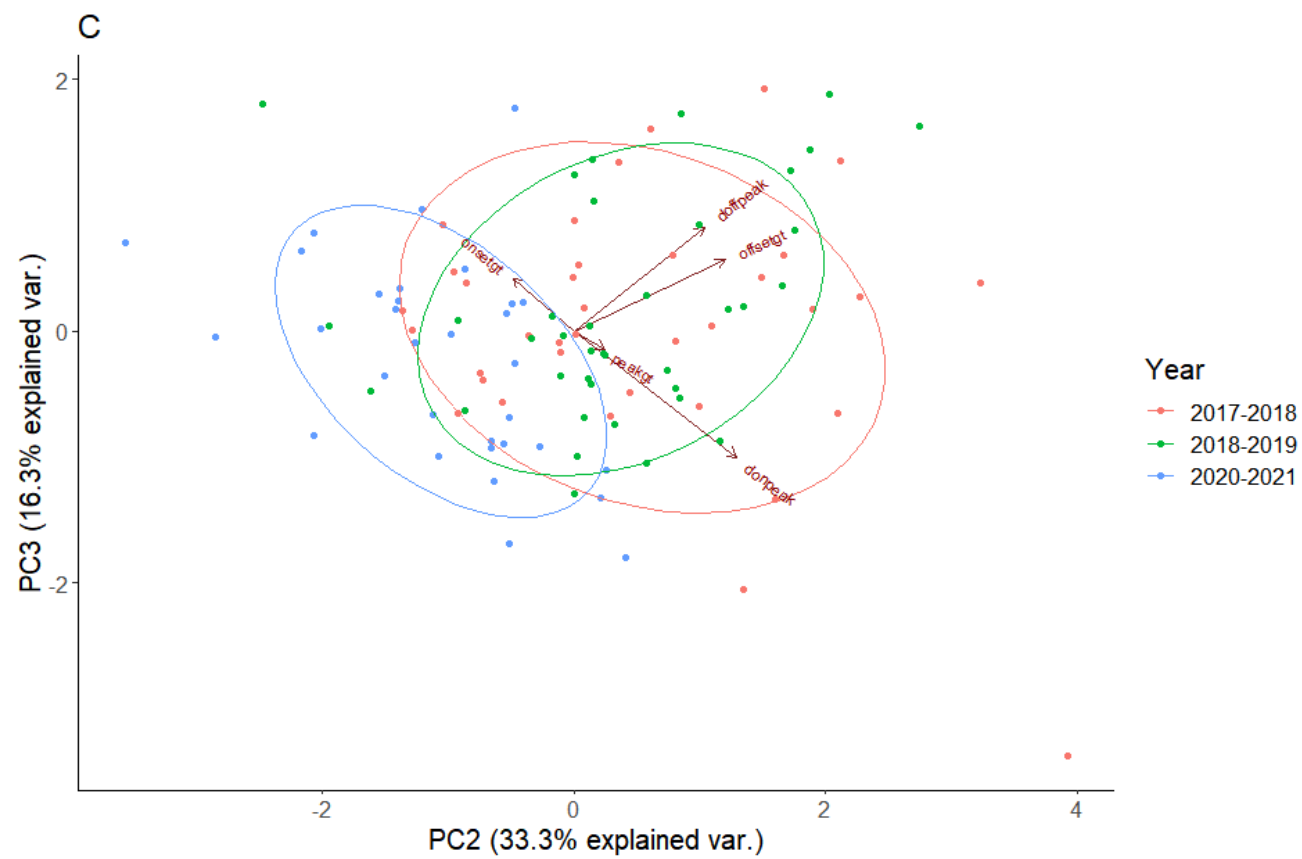
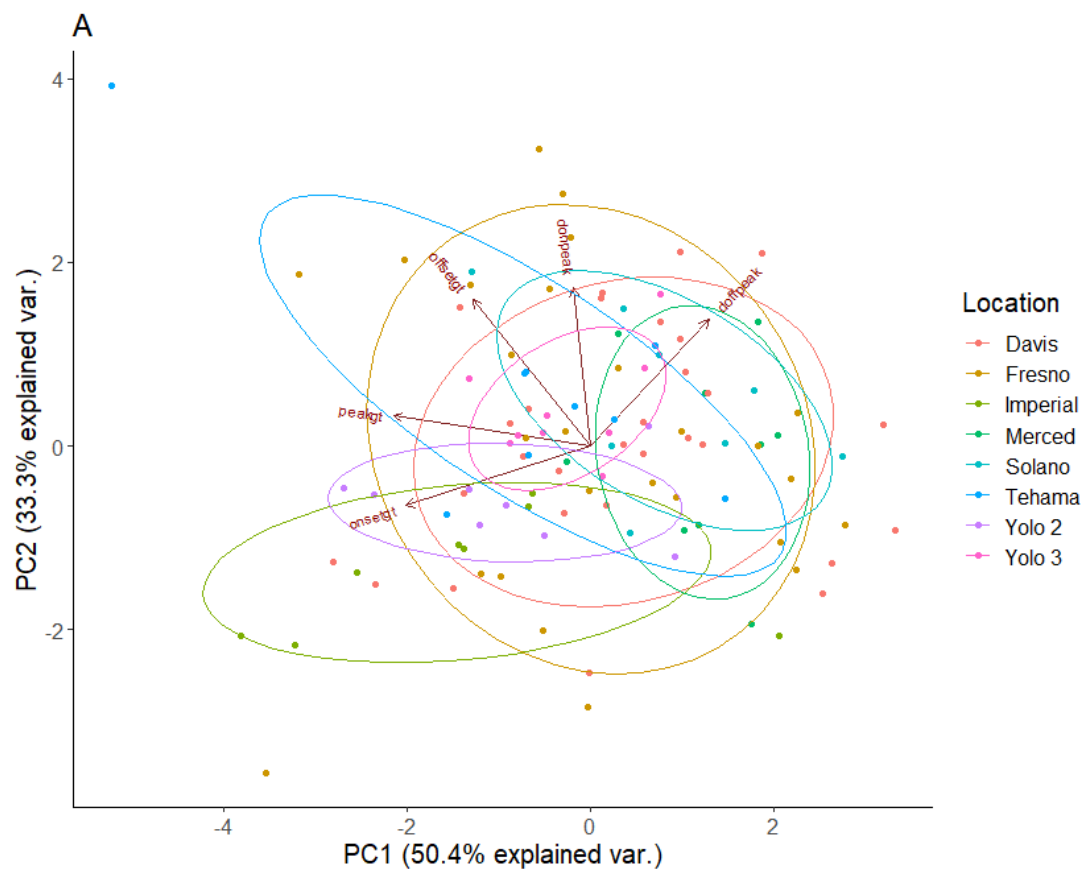


Figure S3. Year based biplots of starch GT traits A) PCA scree plot; PCs B) 1 and 3; C) 2 and 3.



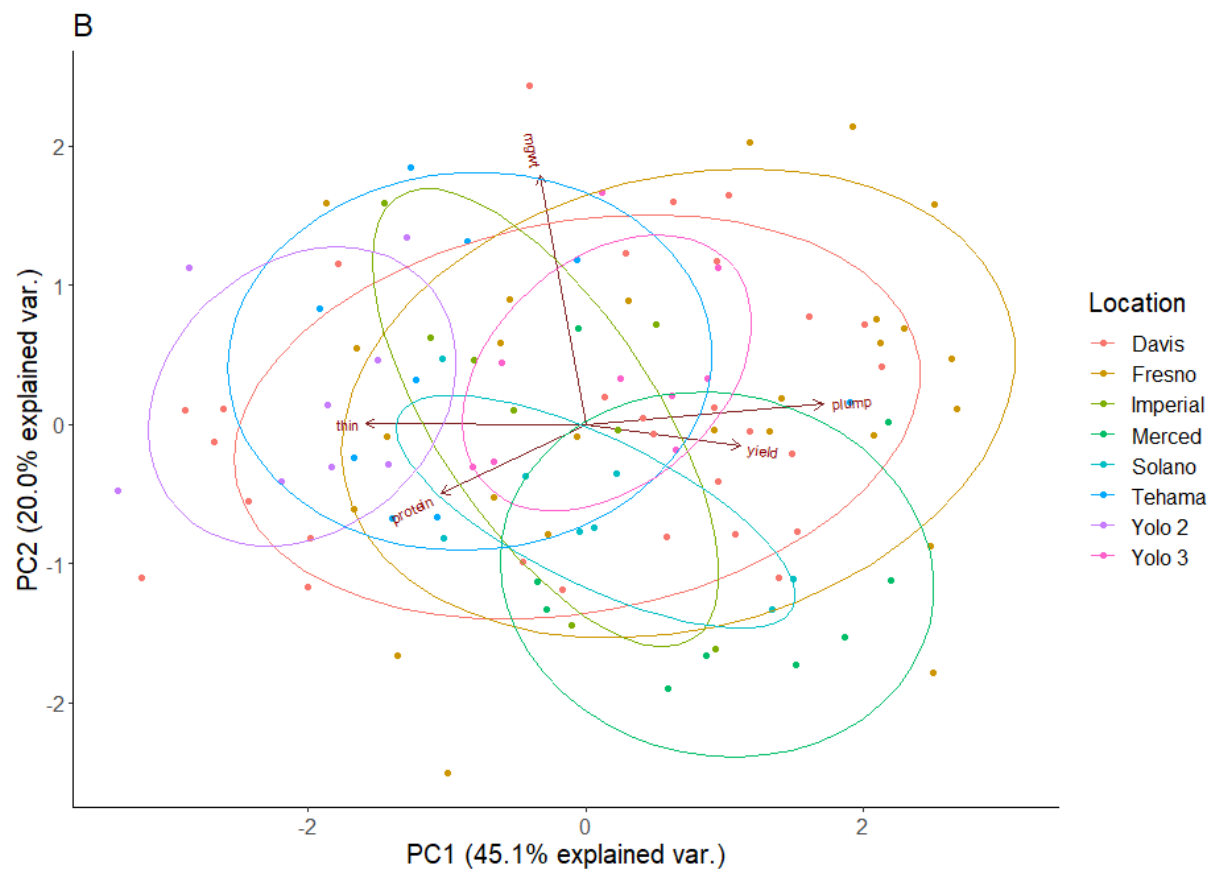


Figure S4. Location based biplots for A) PCs 1 and 2 of starch GT traits; B) PCs 1 and 2 of productivity and quality traits.