

Supplementary Materials

Table S1. Seed transfer zones (STZs) and populations used in our analyses. Population 133 was removed from all analyses due to low reproductive success. Stages show numbers of individuals that flowered, that lived but did not flower (vegetative), and that died in each population. The last two columns show distances between the nearest and farthest populations sampled within the same STZ.

STZ	Population	Flowering	Vegetative	Dead	Elevation (m)	Nearest (km)	Farthest (km)
3a	123	6	5	9	380	54	214
	133	1	4	15	306	54	169
	143	12	2	6	294	42	158
	148	16	2	2	445	42	110
	160	9	6	5	546	110	214
4	220	12	1	7	180	25	44
	224	10	4	6	941	13	31
	226	15	2	3	1145	23	38
	227	11	6	3	1112	13	30
	234	14	3	3	800	19	44
6a	115	16	1	3	794	106	162
	134	15	3	2	510	30	56
	141	19	0	1	487	26	135
	144	16	3	1	269	26	162
6b	118	11	3	6	848	118	171
	130	13	3	4	754	26	119
	137	17	1	2	973	13	119
	140	16	2	2	1301	13	113
	147	19	0	1	676	62	171
7a	103	19	0	1	891	74	139
	105	11	1	8	759	36	99
	229	15	2	3	1132	32	74
	236	16	2	2	1091	5	134
	237	17	1	2	1062	5	139
7b	114	13	4	3	1436	19	90
	119	8	6	6	1365	19	72
	126	10	2	8	1251	28	57
	132	15	2	3	1611	9	82
	136	18	0	2	1399	9	90
Totals		390	71	119			

Table S2. BBCH score criteria used to quantify the reproductive phenology of each flower spike. Anthesis was defined as a score between 6.1 and 6.9. Ripening is defined as a score of between 7.5 and 8.1. Dispersal is defined as a score of between 8.1 and 9.0. Scores of 7.0 – 7.4 reflect the fruit development stage (absence of anthers, preceding the development of viable seed) Lastly, optimum harvest is defined as a score between 7.5 and 8.1.

Stage	BBCH Score	Description
Vegetative	0	Alive with no flowering spikes
	5	Alive pre-anthesis
Anthesis	6.1	Anthers visible on 10% spikelets per spike
	6.3	Anthers visible on 10% - 30% of spikelets per spike
	6.5	Anthers visible on 30% - 50% of spikelets per spike
	6.8	Only dried anthers are visible
Ripening, Development	7.1	No anthers visible; green fresh spikelets
	7.3	No anthers visible; yellowing or browning on spikelet
Ripening, Harvest	7.5	No anthers, yellowing or browning and seed swelling
	7.8	Spikelets yellow or brown and papery; minimal green
Dispersal	8.1	1-10% of seeds per spike have dispersed
	8.3	11-30% of seeds per spike have dispersed
	8.5	31-50% of seeds per spike have dispersed
	8.9	51-90% of seeds per spike have dispersed

Tables S3a-e. Same as the phenology heat map for STZ 3a in Table 2, but for STZ 4 (Table S3a), STZ 6a (Table S3b), STZ 6b (Table S3c), STZ 7a (Table S3d), and STZ 7b (Table S3e).

Table S3a. STZ 4

n=61	CD	2-Jun	9-Jun	12-Jun	16-Jun	21-Jun	24-Jun	28-Jun	2-Jul	6-Jul	10-Jul	18-Jul	22-Jul	26-Jul	30-Jul	3-Aug
Score	GDD	596	703	723	745	782	812	867	926	973	1016	1098	1138	1202	1265	1309
6.1	Anthesis	5	17	0	3	8	1	2	2	0	0	0	1	0	0	0
6.2		1	6	0	0	1	0	0	0	0	0	0	0	0	0	0
6.3		1	3	0	0	0	0	1	1	0	0	0	0	0	0	0
6.4		0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
6.5		0	0	0	0	3	0	0	1	0	0	0	0	0	0	0
6.6		0	0	1	0	3	0	0	0	0	0	0	0	0	0	0
6.7		0	0	0	0	2	1	2	0	0	0	0	0	0	0	0
6.8		0	0	5	3	7	2	2	0	1	0	0	0	1	0	0
	Sum	7	27	6	6	24	4	7	5	1	0	0	1	1	0	0
6.9	Development	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
7.0		0	0	3	1	0	0	1	0	0	0	0	0	0	0	0
7.1		0	4	22	26	10	4	2	5	3	2	0	0	0	1	0
7.2		0	0	0	0	0	4	1	0	1	1	0	0	0	0	0
7.3		0	0	0	1	6	13	13	1	0	2	0	1	0	0	0
	Sum	0	4	25	28	16	21	18	7	5	5	0	1	0	1	0
7.4	Harvest	0	0	0	0	0	5	5	1	0	1	0	0	0	0	0
7.5		0	0	0	0	0	10	12	24	5	9	5	4	2	0	1
7.6		0	0	0	0	0	0	0	0	3	2	0	0	1	0	0
7.7		0	0	0	0	0	0	0	1	1	2	0	1	0	0	0
7.8		0	0	0	0	0	0	0	9	11	36	9	5	3	1	0
7.9		0	0	0	0	0	0	0	0	3	0	3	1	0	0	0
8.0		0	0	0	0	0	0	0	0	5	1	9	0	0	0	1
8.1		0	0	0	0	0	0	0	0	5	1	13	6	3	2	2
	Sum	0	0	0	0	0	15	17	35	33	52	39	17	9	3	4
8.2	Dispersal	0	0	0	0	0	0	0	0	3	1	5	3	1	2	0
8.3		0	0	0	0	0	0	0	0	3	1	7	6	2	1	2
8.4		0	0	0	0	0	0	0	0	2	0	2	0	2	0	0
8.5		0	0	0	0	0	0	0	0	0	0	1	14	3	2	0
8.6		0	0	0	0	0	0	0	0	0	0	3	0	1	0	0
8.7		0	0	0	0	0	0	0	0	0	0	0	0	5	7	5
8.8		0	0	0	0	0	0	0	0	0	1	0	0	0	2	3
8.9		0	0	0	0	0	0	0	0	0	0	3	19	36	42	46
	Sum	0	0	0	0	0	0	0	0	8	3	21	42	50	56	56

Table S3b. STZ 6a.

n=66	CD	2-Jun	9-Jun	12-Jun	16-Jun	21-Jun	24-Jun	28-Jun	2-Jul	6-Jul	10-Jul	18-Jul	22-Jul	26-Jul	30-Jul	3-Aug
Score	GDD	596	703	723	745	782	812	867	926	973	1016	1098	1138	1202	1265	1309
6.1	Anthesis	18	14	0	1	6	0	2	0	0	0	0	1	0	0	0
6.2		7	4	0	0	1	0	0	0	0	0	0	0	0	0	0
6.3		2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4		0	2	0	0	0	0	0	1	0	0	0	0	0	0	0
6.5		0	2	0	0	3	0	0	0	0	0	0	0	0	0	0
6.6		0	2	0	0	2	1	0	0	0	0	0	0	0	0	0
6.7		0	1	1	0	1	0	4	0	0	0	0	0	0	0	0
6.8		0	3	6	2	13	1	4	1	0	0	0	0	0	0	0
	Sum	27	30	7	3	26	2	10	2	0	0	0	1	0	0	0
6.9	Development	0	1	1	0	0	0	2	3	0	0	0	0	0	0	0
7.0		0	0	5	2	0	0	3	2	0	0	0	0	0	0	0
7.1		0	9	27	33	17	7	2	7	1	1	0	0	1	0	0
7.2		0	0	0	0	1	3	0	1	0	0	0	0	1	0	0
7.3		0	0	0	4	6	21	12	5	4	7	1	0	0	1	0
	Sum	0	10	33	39	24	31	19	18	5	8	1	0	2	1	0
7.4	Harvest	0	0	0	0	0	3	1	0	3	1	1	0	1	0	0
7.5		0	0	0	0	0	14	20	21	11	17	0	2	0	0	1
7.6		0	0	0	0	0	0	0	1	8	7	3	2	0	0	0
7.7		0	0	0	0	0	0	0	0	4	2	2	4	0	0	0
7.8		0	0	0	0	0	0	0	12	9	28	16	10	3	0	0
7.9		0	0	0	0	0	0	0	0	2	1	6	0	1	1	1
8.0		0	0	0	0	0	0	0	0	1	1	11	4	2	1	0
8.1		0	0	0	0	0	0	0	0	5	0	15	7	2	3	1
	Sum	0	0	0	0	0	17	21	34	43	57	54	29	9	5	3
8.2	Dispersal	0	0	0	0	0	0	0	0	3	1	4	3	2	1	0
8.3		0	0	0	0	0	0	0	0	2	0	6	3	4	0	1
8.4		0	0	0	0	0	0	0	0	1	0	0	5	4	1	2
8.5		0	0	0	0	0	0	0	0	0	0	1	12	7	5	3
8.6		0	0	0	0	0	0	0	0	0	0	0	0	3	3	6
8.7		0	0	0	0	0	0	0	0	0	0	0	0	8	12	9
8.8		0	0	0	0	0	0	0	0	0	0	0	0	2	5	8
8.9		0	0	0	0	0	0	0	0	0	0	0	13	25	33	34
	Sum	0	0	0	0	0	0	0	0	6	1	11	36	55	60	63

Table S3c. STZ 6b.

n=78	CD	2- Jun	9- Jun	12- Jun	16- Jun	21- Jun	24- Jun	28- Jun	2- Jul	6- Jul	10- Jul	18- Jul	22- Jul	26- Jul	30- Jul	3- Aug
Score	GDD	596	703	723	745	782	812	867	926	973	1016	1098	1138	1202	1265	1309
6.1	Anthesis	24	26	0	3	12	0	2	1	0	0	0	0	0	0	0
6.2		7	4	0	0	0	0	0	0	0	0	0	0	0	0	0
6.3		3	4	0	0	4	1	0	1	0	0	0	0	0	0	0
6.4		0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
6.5		0	2	1	0	12	2	2	0	0	0	0	0	0	0	0
6.6		0	2	0	0	6	0	1	0	0	0	0	0	0	0	0
6.7		0	1	0	0	9	1	5	0	0	0	0	0	0	0	0
6.8		0	2	6	2	7	2	6	4	1	0	0	0	0	0	0
	Sum	34	42	7	5	51	6	16	6	1	0	0	0	0	0	0
6.9	Development	0	1	1	0	1	0	5	1	0	0	0	0	0	0	0
7.0		0	2	8	2	1	3	3	3	0	0	0	0	0	0	0
7.1		0	10	35	47	8	13	5	5	1	2	0	0	1	0	0
7.2		0	0	1	1	1	10	0	4	0	2	0	0	1	0	0
7.3		0	0	0	2	6	20	13	8	5	6	1	2	1	0	0
	Sum	0	13	45	52	17	46	26	21	6	10	1	2	3	0	0
7.4	Harvest	0	0	0	0	0	7	8	7	5	4	0	0	0	0	0
7.5		0	0	0	0	0	10	15	16	17	14	6	4	3	1	0
7.6		0	0	0	0	0	0	0	4	9	9	3	2	1	0	0
7.7		0	0	0	0	0	0	1	4	8	9	4	4	1	0	0
7.8		0	0	0	0	0	0	1	16	3	19	12	10	2	3	1
7.9		0	0	0	0	0	0	0	0	3	0	7	1	0	0	0
8.0		0	0	0	0	0	0	0	0	2	3	10	6	2	1	0
8.1		0	0	0	0	0	0	0	0	5	3	6	5	6	2	3
	Sum	0	0	0	0	0	17	25	47	52	61	48	32	15	7	4
8.2	Dispersal	0	0	0	0	0	0	0	0	4	1	4	6	3	1	0
8.3		0	0	0	0	0	0	0	0	4	2	8	3	6	3	2
8.4		0	0	0	0	0	0	0	0	2	0	5	6	6	5	4
8.5		0	0	0	0	0	0	0	0	2	1	3	4	3	2	2
8.6		0	0	0	0	0	0	0	0	0	1	1	0	2	5	5
8.7		0	0	0	0	0	0	0	0	1	0	3	3	3	10	8
8.8		0	0	0	0	0	0	0	0	0	1	1	1	4	6	8
8.9		0	0	0	0	0	0	0	0	1	1	4	20	32	38	43
	Sum	0	0	0	0	0	0	0	0	14	7	29	43	59	70	72

Table S3d. STZ 7a.

n=78	CD	2-Jun	9-Jun	12-Jun	16-Jun	21-Jun	24-Jun	28-Jun	2-Jul	6-Jul	10-Jul	18-Jul	22-Jul	26-Jul	30-Jul	3-Aug
Score	GDD	596	703	723	745	782	812	867	926	973	1016	1098	1138	1202	1265	1309
6.1	Anthesis	11	9	0	0	10	0	3	1	0	0	0	1	0	0	0
6.2		3	12	0	0	2	0	0	0	0	0	0	0	0	0	0
6.3		0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
6.4		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5		0	0	1	0	2	0	0	0	0	0	0	0	0	0	0
6.6		0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
6.7		0	0	0	0	1	0	3	0	0	0	0	0	0	0	0
6.8		0	0	2	1	3	1	2	0	1	0	0	0	0	0	0
	Sum	14	27	3	2	18	1	10	1	1	0	0	1	0	0	0
6.9	Development	0	1	3	0	0	0	0	2	0	0	0	0	0	0	0
7.0		0	0	1	2	0	0	2	0	0	0	0	0	0	0	0
7.1		0	4	23	23	10	9	2	1	2	1	0	0	1	1	1
7.2		0	0	0	1	0	2	1	2	0	0	0	0	0	0	0
7.3		0	0	0	2	13	14	7	5	4	4	1	0	0	0	0
	Sum	0	5	27	28	23	25	12	10	6	5	1	0	1	1	1
7.4	Harvest	0	0	0	0	0	1	1	4	2	1	0	0	1	0	0
7.5		0	0	0	0	0	15	22	16	5	10	1	1	0	0	0
7.6		0	0	0	0	0	0	0	0	3	4	1	0	0	0	0
7.7		0	0	0	0	0	0	0	1	2	3	3	2	0	0	0
7.8		0	0	0	0	0	0	0	12	11	48	6	5	2	0	0
7.9		0	0	0	0	0	0	0	0	2	3	9	2	0	0	0
8.0		0	0	0	0	0	0	0	0	4	0	6	2	0	1	1
8.1		0	0	0	0	0	0	0	0	7	2	25	7	2	0	0
	Sum	0	0	0	0	0	16	23	33	36	71	51	19	5	1	1
8.2	Dispersal	0	0	0	0	0	0	0	0	1	0	9	0	1	0	0
8.3		0	0	0	0	0	0	0	0	1	0	4	4	3	1	0
8.4		0	0	0	0	0	0	0	0	0	0	2	1	0	2	2
8.5		0	0	0	0	0	0	0	0	0	0	5	22	4	0	1
8.6		0	0	0	0	0	0	0	0	0	1	2	1	0	1	0
8.7		0	0	0	0	0	0	0	0	0	0	1	2	14	15	16
8.8		0	0	0	0	0	0	0	0	0	0	0	0	2	2	1
8.9		0	0	0	0	0	0	0	0	0	0	2	28	48	55	56
	Sum	0	0	0	0	0	0	0	0	2	1	25	58	72	76	76

Table S3e. STZ 7b.

n=65	CD	2-Jun	9-Jun	12-Jun	16-Jun	21-Jun	24-Jun	28-Jun	2-Jul	6-Jul	10-Jul	18-Jul	22-Jul	26-Jul	30-Jul	3-Aug
Score	GDD	596	703	723	745	782	812	867	926	973	1016	1098	1138	1202	1265	1309
6.1	Anthesis	13	11	0	2	7	0	8	5	0	1	0	4	0	0	0
6.2		1	6	0	0	3	0	0	0	0	0	0	0	0	0	0
6.3		1	1	0	1	3	0	2	4	0	0	0	0	1	1	1
6.4		0	3	0	0	4	0	1	1	0	0	0	0	0	0	0
6.5		0	1	3	0	4	2	2	0	2	0	0	0	0	0	0
6.6		0	2	0	0	3	0	2	0	0	0	0	1	0	0	0
6.7		0	0	0	0	4	0	3	2	1	1	0	1	1	0	0
6.8		0	0	2	6	7	4	8	3	2	1	1	1	2	3	2
	Sum	15	24	5	9	35	6	26	15	5	3	1	7	4	4	3
6.9	Development	0	1	1	0	0	0	3	1	0	0	0	0	1	0	0
7.0		0	1	3	0	0	2	5	6	2	1	0	0	2	0	0
7.1		0	4	19	20	4	8	3	6	9	13	1	4	5	1	1
7.2		0	0	0	1	0	6	1	4	2	0	1	0	0	0	0
7.3		0	0	0	1	2	13	5	9	5	8	5	6	2	2	0
	Sum	0	6	23	22	6	29	17	26	18	22	7	10	10	3	1
7.4	Harvest	0	0	0	0	0	1	2	6	5	7	2	3	0	1	0
7.5		0	0	0	0	0	4	5	5	12	10	10	5	6	3	1
7.6		0	0	0	0	0	0	0	1	6	8	3	2	0	3	1
7.7		0	0	0	0	0	0	0	1	2	3	7	0	0	0	2
7.8		0	0	0	0	0	0	0	4	4	9	8	4	8	2	3
7.9		0	0	0	0	0	0	0	0	3	0	5	3	1	0	1
8.0		0	0	0	0	0	0	0	0	0	0	7	9	2	0	0
8.1		0	0	0	0	0	0	0	0	3	0	8	1	3	4	4
	Sum	0	0	0	0	0	5	7	17	35	37	50	27	20	13	12
8.2	Dispersal	0	0	0	0	0	0	0	0	0	0	1	2	3	3	4
8.3		0	0	0	0	0	0	0	0	0	0	1	1	3	4	2
8.4		0	0	0	0	0	0	0	0	0	0	2	1	2	5	3
8.5		0	0	0	0	0	0	0	0	0	0	0	9	4	2	7
8.6		0	0	0	0	0	0	0	0	0	0	0	1	4	4	3
8.7		0	0	0	0	0	0	0	0	0	0	0	2	2	3	4
8.8		0	0	0	0	0	0	0	0	0	0	0	0	1	3	3
8.9		0	0	0	0	0	0	0	0	0	0	0	4	12	21	22
	Sum	0	0	0	0	0	0	0	0	0	0	4	20	31	45	48