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Soybean variety evaluation, Grafton, NSW 2019–20

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Key findings

- The late 23 January sowing date and low rainfall during pod-fill affected crop growth.
- The variety HaymanA performed well in the experiment maturing 126 days after planting (DAP) and yielding 3.95 t/ha. It had a large seed size (24.5 g/100 seed), high protein (45.9% dry matter basis (DMB)), a weathering tolerance of 66.9% unweathered grain and a low lodging score (1.2).
- The yield of the variety New Bunya HB1$^{(\phi)}$ was statistically equivalent to the variety Hayman$^{(\phi)}$, however, its low weathering tolerance of 56% unweathered grain is a concern for coastal soybean production.
- None of the breeding lines evaluated in this experiment produced yield significantly higher than Hayman$^{(\phi)}$, however, 12 lines produced a yield that was statistically similar.
- The breeding lines 19-7 and 19-58 have potential for high yield and weathering tolerance equivalent to current commercial varieties. These lines will be advanced to future evaluations.

Introduction

The Australian Soybean Breeding Program (ASBP) field evaluates new soybean (Glycine max) breeding lines to assess suitability to the diverse farming systems and production regions of northern New South Wales (NSW), including the north coast, Northern Tablelands and slopes.

Lines are evaluated for yield potential and other traits that confer superior agronomic performance and profitability, including tolerance to diseases and lodging, maturity, and tolerance to pre-harvest weathering damage. Grain protein and oil concentrations, and seed size are also assessed. Advanced lines are included in experiments on a range of sowing dates from mid November to late January. This report presents the results of the late (23 January) sowing date variety evaluation from the 2019–20 summer.

Site details

Location	NSW DPI, Grafton Primary Industries Institute, Experiment Farm Road, Grafton, NSW (Latitude 29°62'53.77" S, Longitude 152° 96'09.75" E). Paddock 19A: 29°37'16.0S 152°56'58.5E.
Paddock history	The experiment site was cropped to Bogong triticale in winter 2019 and soybean in summer 2018–19. This paddock was converted to a raised bed, controlled traffic farming system in 2017. The beds have furrows at 1.8 m centres and a plantable bed top width of 1.5 m, on which four rows of soybean are planted on 30 cm row spacings.
Soil type and nutrition	Deep red loam. Soil analysis is presented in Table 1.

Table 1 Site soil chemical characteristics for 0–10 cm depth.

Soil measurement and unit	Value (highest)	Value (lowest)
Soil pH (1:5 water)	5.92	5.45
Sulphate sulfur (mg/kg)	17	16
Nitrate nitrogen (mg/kg)	57	55
Ammonium nitrogen (mg/kg)	0.6	1
Phosphorus (mg/kg) [Bray 1 test][a]	3.3	3.8
Phosphorus (mg/kg) [Bray 2 test][a]	6.3	7.4
Phosphorus (mg/kg) [Colwell P test]	19	21
Potassium (%)	7.3	7.4
Calcium (mg/kg)	1084	873
Magnesium (%)	10.9	14.1
Sodium (mg/kg)	16	<15
Aluminium (mg/kg)	<1	<1
Electrical conductivity (dS/m)	0.107	0.097
Effective cation exchange capacity (ECEC) (cmol+/kg)	6.75	5.72
Zinc (mg/kg)	0.8	1
Copper (mg/kg)	0.8	0.8
Iron (mg/kg)	42	53
Manganese (mg/kg)	96	99
Silicon (mg/kg)	37	35
Boron (mg/kg)	0.51	0.54

[a] Bray 1 and Bray 2 analyses use different concentrations of ammonium fluoride extractant to give an estimation of P reserves in the soil.

Rainfall and temperature for summer 2019–20

A total of 880 mm of rainfall was received during the growing season, predominantly during the months of January and February, which were above the long-term average (Figure 1). The remaining months of the growing season were below average rainfall. Growing degree days (GDD) (using a base of 10) for this experiment totalled 2306. (The base number when referring to GDD, is the plant's optimal base temperature e.g. winter crops have base five and many summer plants are base 10).

Experiment design

- 36 entries.
- Four replicates in a randomised, complete block design.
- Plot size was four rows wide and eight metre long.

Sowing date

23 January, 2020.

Fertiliser

- 130 kg/ha of sulphate of potash applied on 1 December.
- 280 kg/ha of superphosphate with molybdenum applied at planting.

Plant population

The target plant population was 45 plants/m^2, which is recommended for later sowing dates in this location. The result was 42 plants/m^2 for most plots, except for three breeding lines, which has been accounted for in spatial analysis of the data.

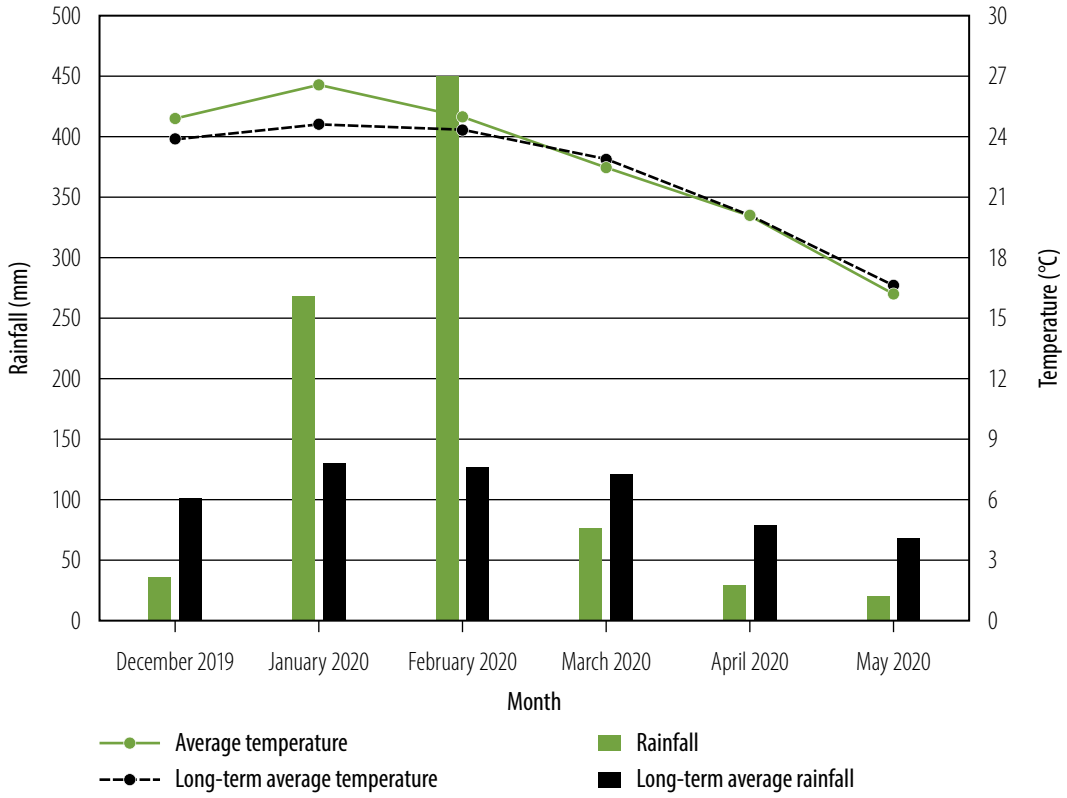


Figure 1 Monthly total rainfall and monthly average temperature for summer 2019–20 and long-term averages at NSW DPI Grafton.

Weed management	Pre plant knockdown: Roundup® 2 L/ha (540 g/l glyphosate) + Terrain® 30 g/ha (500 g/kg flumioxazin) applied 20 December 2019. Pre emergence: Roundup® 500 ml/ha (540 g/l glyphosate) + Dual Gold® 1 L/ha (960 g/L S-metolachlor) + Spinnaker® 140 g/ha (700 g/kg imazethapyr) applied on 24 January 2020.
Insect management	Targeting *Zygrita diva:* Legion® 200 ml/100 kg seed (500 g/L fipronil) applied 23 January 2020. Targeting *Helicoverpa* spp.: ViVus Max® 150 mL/ha (5 × 109 polyhedral inclusion bodies of the nucleopolyhedrovirus of *Helicoverpa armigera* per millilitre) applied 1 February and 11 February 2020 Targeting *Nezara viridula* and *Melanacanthus margineguttatus*: Shield® 250 mL/ha (200 g/L clothianidin) applied 3 March. Targeting *Nezara viridula* and *Melanacanthus margineguttatus*: Lannate L® 1.5 L/ha (225 g/L methomyl) applied 24 April 2020. Targeting *Nezara viridula* and *Melanacanthus margineguttatus*: Decis® 0.5 L/ha (50 g/L deltamethrin) applied 6 May 2020
Disease management	Targeting soybean leaf rust: Folicur® 350 mL/ha (430 g/L tebuconazole) applied 6 May 2020.
Harvest date	Each variety was harvested when mature from mid May to mid June, 2020.

Treatment

Varieties (36)

Thirty breeding lines from the ASBP were advanced from experiments in previous seasons based on maturity suited to the late planting widow for this region (January) and yield. Six commercial varieties were included in the experiment as benchmarks for various traits. For example, A6785 is a benchmark for small seed size, low grain protein levels and high yield potential. Hayman$^{\Phi}$ is an industry benchmark for large seed size, high grain protein levels and high yield potential with January sowing dates.

Results

Analysed data

The data were analysed by Stephen Morris (Biometrician, NSW DPI Wollongbar) using spatial analysis with an ASReml package (Butler et al. 2017) in the R environment (R Development Core Team 2017). Differences between results that exceed the estimate of least significant difference (l.s.d.) can be regarded as statistically significant at the 5% critical value (P<0.05).

In this experiment, 13 varieties, including Hayman$^{\Phi}$, produced significantly higher yield than the other varieties (l.s.d. 0.33 t/ha). The analysed data are presented in Table 2 and in Figure 1, with the industry standards highlighted in red (Hayman$^{\Phi}$ and A6785).

The 13 highest yielding varieties in this experiment all produced grain protein of >40% DMB, which is the critical industry receival standard for soybean.

In relation to weathering tolerance, lines 19-102, New Bunya HB1$^{\Phi}$ and T1834-2 have low levels, equivalent to the variety Warrigal, which is the low benchmark for this trait (50% unweathered grain). Weathering tolerance data are presented in Figure 2 with the industry benchmark for this trait highlighted in red (variety Zeus is the high benchmark for this trait).

Lodging is a measure of a plant's ability to remain upright. The lodging score applied to this experiment is measured on a 1 to 5 scale where 1 is erect and 5 is flat (Table 2).

Table 2 Analysed data of soybean breeding line evaluation 2019-20, NSW DPI Grafton. Data are ranked for yield.

	Variety	Yield (t/ha)[a]	Maturity (DAP)[b]	Plant height (cm)	Protein (% DMB)[c]	Oil (% DMB)[c]	Seed size (g/100 seed)	Seed size (# seed/kg)	Weathering tolerance (%)[d]	Lodging[e]
1	19-102	3.98	136	78.8	43.3	19.5	25.8	3880	53.7	2.4
2	19-58	3.98	137	75.5	44.3	18.2	30.5	3282	79.3	2.4
3	Hayman(Φ)	3.95	126	95.3	45.9	18.3	24.5	4077	66.9	1.6
4	New Bunya HB1(Φ)	3.86	129	76.0	45.9	17.5	24.0	4161	56.0	1.9
5	16-181	3.83	139	96.0	42.7	19.0	19.7	5068	69.7	3.3
6	19-7	3.83	114	65.4	44.7	18.1	20.8	4801	79.4	1.4
7	19-160	3.82	131	87.4	42.6	19.6	24.4	4098	63.2	2.3
8	19-123	3.78	118	58.8	44.2	18.2	22.7	4405	68.1	1.9
9	19-78	3.78	134	83.3	44.4	18.7	26.3	3807	71.8	2.0
10	T1834-2	3.76	127	60.5	45.4	18.1	27.8	3596	49.9	1.8
11	Warrigal	3.74	127	70.2	44.0	19.1	22.7	4415	50.0	2.6
12	19-54	3.73	135	82.9	44.3	17.9	27.6	3628	65.8	2.5
13	T075-7	3.73	131	71.0	44.1	18.8	21.2	4708	62.2	1.9
14	16-149	3.64	137	94.4	44.4	18.2	19.7	5086	61.9	3.7
15	18-15	3.64	137	95.1	43.0	19.3	25.4	3940	65.9	2.7
16	19-30	3.63	127	72.4	43.0	19.5	22.1	4523	61.5	2.3
17	19-51	3.62	128	77.1	44.9	18.0	24.0	4165	75.4	2.4
18	19-64	3.62	137	82.0	44.1	18.2	25.2	3976	66.0	2.3
19	19-169	3.58	135	70.7	40.9	19.6	26.6	3765	65.0	2.6
20	16-135	3.57	135	90.0	44.5	18.6	19.9	5015	58.4	3.3
21	19-55	3.56	137	73.5	44.3	18.6	26.7	3740	74.3	2.4
22	19-12	3.53	136	91.1	43.5	19.0	22.5	4450	63.8	3.5
23	A6785	3.53	126	73.2	43.2	19.6	16.4	6083	60.0	2.9
24	19-113	3.48	135	77.6	42.5	19.7	22.5	4437	60.4	2.7
25	Zeus	3.47	108	63.7	44.7	19.0	24.2	4137	76.8	1.0
26	19-117	3.46	133	70.7	43.7	18.9	24.7	4055	58.7	2.6
27	19-101	3.45	138	94.2	44.6	18.1	28.1	3556	65.8	2.3
28	19-39	3.43	134	82.7	44.4	18.9	25.3	3960	46.7	2.7
29	19-99	3.42	131	81.9	43.7	19.3	26.2	3818	78.8	2.2
30	19-166	3.37	141	91.0	43.5	19.1	29.5	3386	77.3	2.9
31	19-46	3.23	133	91.4	45.7	17.8	22.0	4554	65.8	3.3
32	19-116	3.22	126	80.9	43.2	18.9	26.4	3784	51.3	2.5
33	18-9	3.02	136	98.6	43.3	19.1	23.0	4346	53.9	3.3
34	19-31	2.99	135	87.5	43.2	19.3	20.4	4912	49.4	3.5
35	19-45	2.7	136	84.9	44.9	18.3	22.5	4437	50.1	3.8
36	Burrinjuck	2.28	108	59.9	46.4	18.4	22.1	4535	43.5	1.1
	se	0.12	1	3.5	0.4	0.2	0.4		1.2	0.3
	l.s.d. (P<0.05)	0.33	4	9.5	1.0	0.6	1.2		3.3	0.7

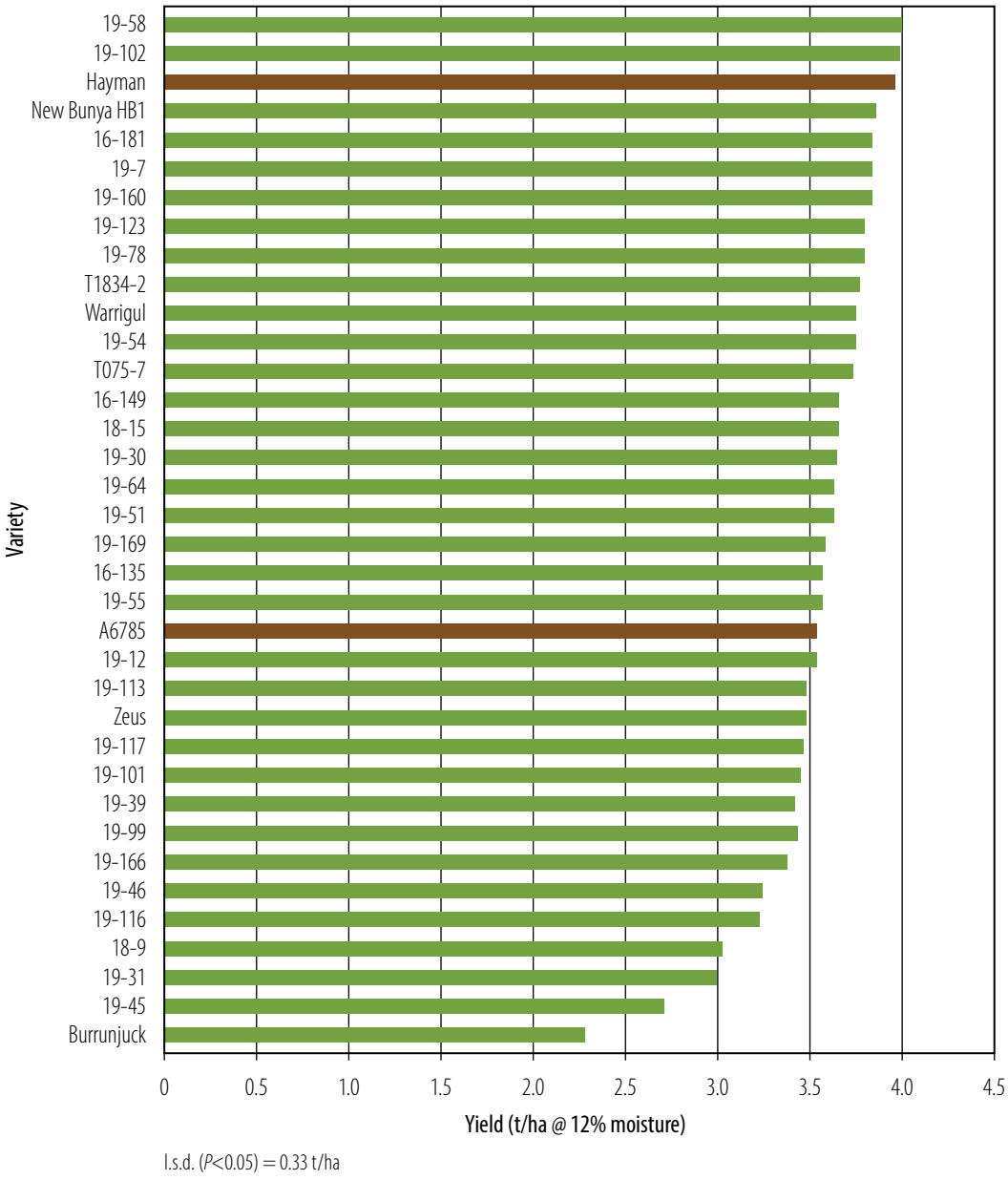
[a] Grain yield is expressed at 12% moisture

[b] Maturity is expressed as days after planting to reach the P95 stage of physiological maturity for soybean, where 95 % of the pods are at full maturity.

[c] Grain protein and oil concentrations are expressed as % DMB

[d] Weathering tolerance is expressed as % unweathered grain

[e] Lodging: 1 = erect; 5 = flat



l.s.d. ($P<0.05$) = 0.33 t/ha

Figure 2 Grain yield of 36 soybean varieties in a variety evaluation at Grafton NSW. Industry benchmark varieties for high yield at a January sowing date (Hayman[Φ] and A6785) are highlighted in brown.

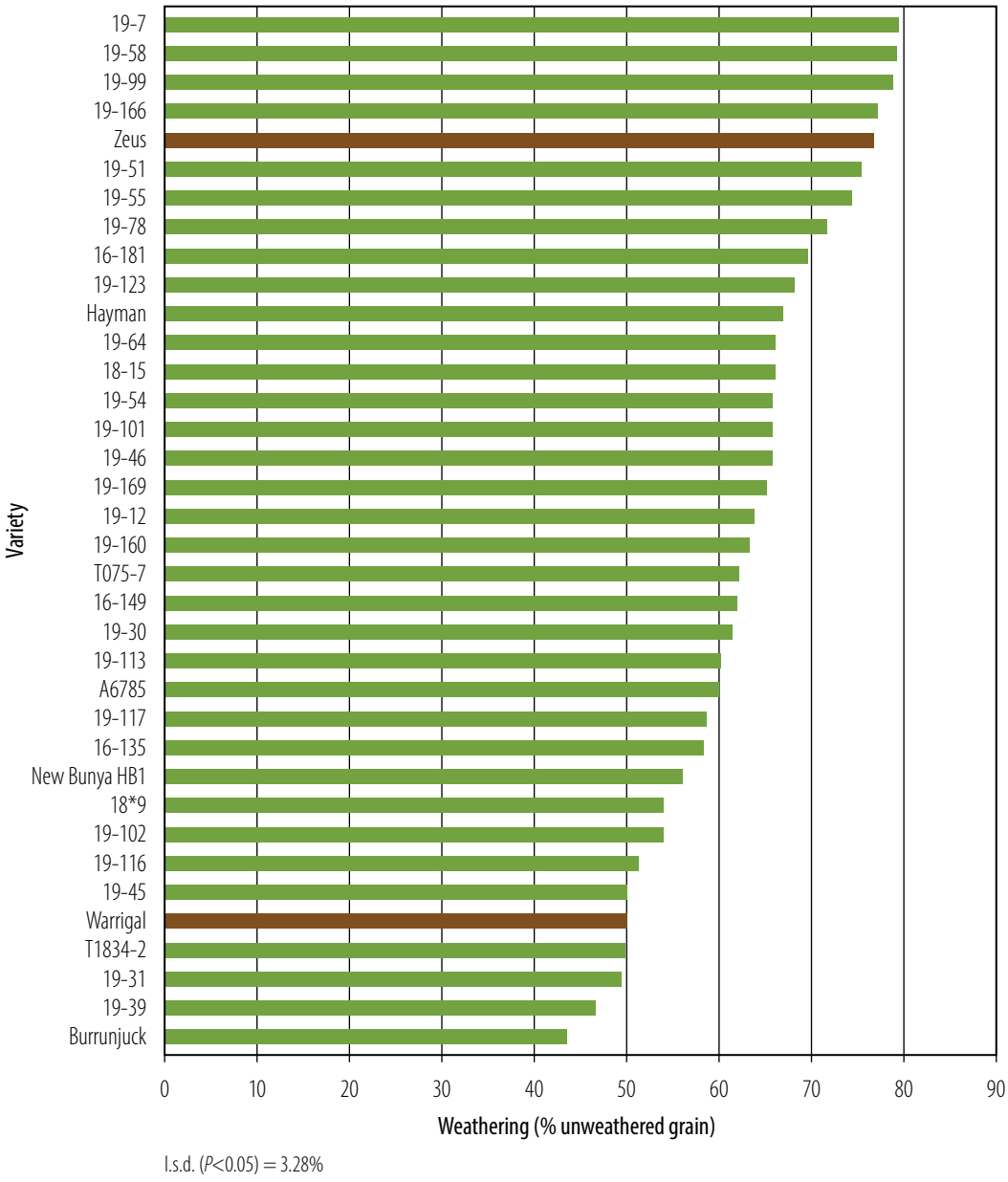


Figure 3 Weathering tolerance of 36 soybean varieties sown at Grafton NSW. Industry benchmark varieties for high (Zeus) and low (Warrigal) weathering tolerance are highlighted in brown.

Conclusions

The late planting date and low rainfall during pod fill was a good test for the breeding lines. In these conditions the variety Hayman$^{\Phi}$ performed well, maturing 126 days after planting and yielding 3.95 t/ha with large seed size (24.5 g/100 seed), high protein (45.9 % DMB), an acceptable level of weathering tolerance (66.9 % unweathered grain) and a low lodging score (1.2 out of 5). None of the breeding lines evaluated in this experiment produced significantly higher yield than Hayman$^{\Phi}$, however, 12 other lines had a statistically similar yield to Hayman$^{\Phi}$.

New Bunya HB1$^{\Phi}$, a variety released in 2020 for Queensland, yielded 3.86 t/ha, which is statistically similar to Hayman$^{\Phi}$. A concern is the variety's low weathering tolerance rating, which was anticipated due to the known low weathering tolerance of its parent variety Bunya. The low weathering tolerance of New Bunya HB1$^{\Phi}$ is a risk for growers in coastal production regions where heavy rain at harvest time is common and can reduce grain quality and yield.

Breeding lines 19-7 and 19-58 will be advanced for future evaluation due to high yield and weathering tolerance. Lines 19-51, 19-55 and 19-99 will also be further evaluated due to their very high levels of weathering tolerance, a critical trait for crop security in coastal production regions.

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