

# Identifying Adapted Lines and Favorable Environments for Malt Barley Production in Texas

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## INTRODUCTION

- In the 1960s, barley (*Horedum vulgare* L.) was grown on nearly 243,000 ha in Texas. Today it is planted on ~16,000 ha, but acres have been increasing.
- Barley in Texas is mainly used for feed and forage for livestock.
- A rise in microbreweries in Texas has increased interest of locally grown malt ingredients. There are currently 189 craft breweries in Texas, producing a total of 1,135,043 barrels per year (Brewer's Association).
- Criteria for barley malt quality have been established by the American Malting Barley Association (AMBA) for important characteristics, such as kernel plumpness and protein content.
- Increased demand by dairies is helping to support feed grain barley prices.
- Currently there is no active barley breeding program to breed lines specifically for Texas climates.
- Lines for this study were obtained from the Triticeae Coordinated Agricultural Project (TCAP).

AMBA Malting Barley Breeding Guidelines		
Quality Parameter	Six-Row	Two-Row
Plump Kernels (on 6/64")	> 80%	> 90%
Malt Extract (%)	>79%	>81%
Barley Protein (%)	< 13%	< 12%
Wort Protein (%)	5.2-5.7%	<5.3%
Soluble/Total Protein (%)	42-47%	38-45%
Diastatic Power (*ABSC)	> 150	110-150
Alpha Amylase (20° DU)	> 50	40-70
Beta-Glucan (ppm)	< 120	< 100
FAN (ppm)	> 210	140-190

## RESEARCH OBJECTIVES

- Determine if barley malt quality is closely associated with yield or test weight across different barley types and environments to expedite early screening of breeding lines for malt production.
- Determine which environments in Texas are most conducive to malt barley production.
- Evaluate a range of barley types and breeding lines in order to identify adapted lines that can be grown under Texas environments for craft malting which are superior to commercial varieties.

## MATERIALS & METHODS

- 505 spring and 303 winter barley lines were planted in 0.9 m long headrows using a Hege 1000 HR plot drill in 2014.
- 224 spring and 136 winter lines were selected based on 2014 yield and planted again in 2015 and 2016 in small plots (1.5 x 3.4 m) (Fig. 1) in 3 locations (Fig. 2):
  - Dimmitt, TX [DIM] (irrigated, winter lines only) – High Plains Region
  - Castroville, TX [CAS] (irrigated) – South Texas Plains Region
  - McGregor, TX [MCG] (dryland) – Blacklands Region
- Experimental design was an augmented single rep design with repeating checks in 2014 and 2015 due to limited seed. A two replicate alpha lattice design was used in 2016 as more seed was available for more replications.
- Plots were mechanically harvested using a Wintersteiger nursery combine.
- Harvested grain samples were sent to the USDA ARS Cereal Crops Research Laboratory in Madison, WI for malt quality testing.

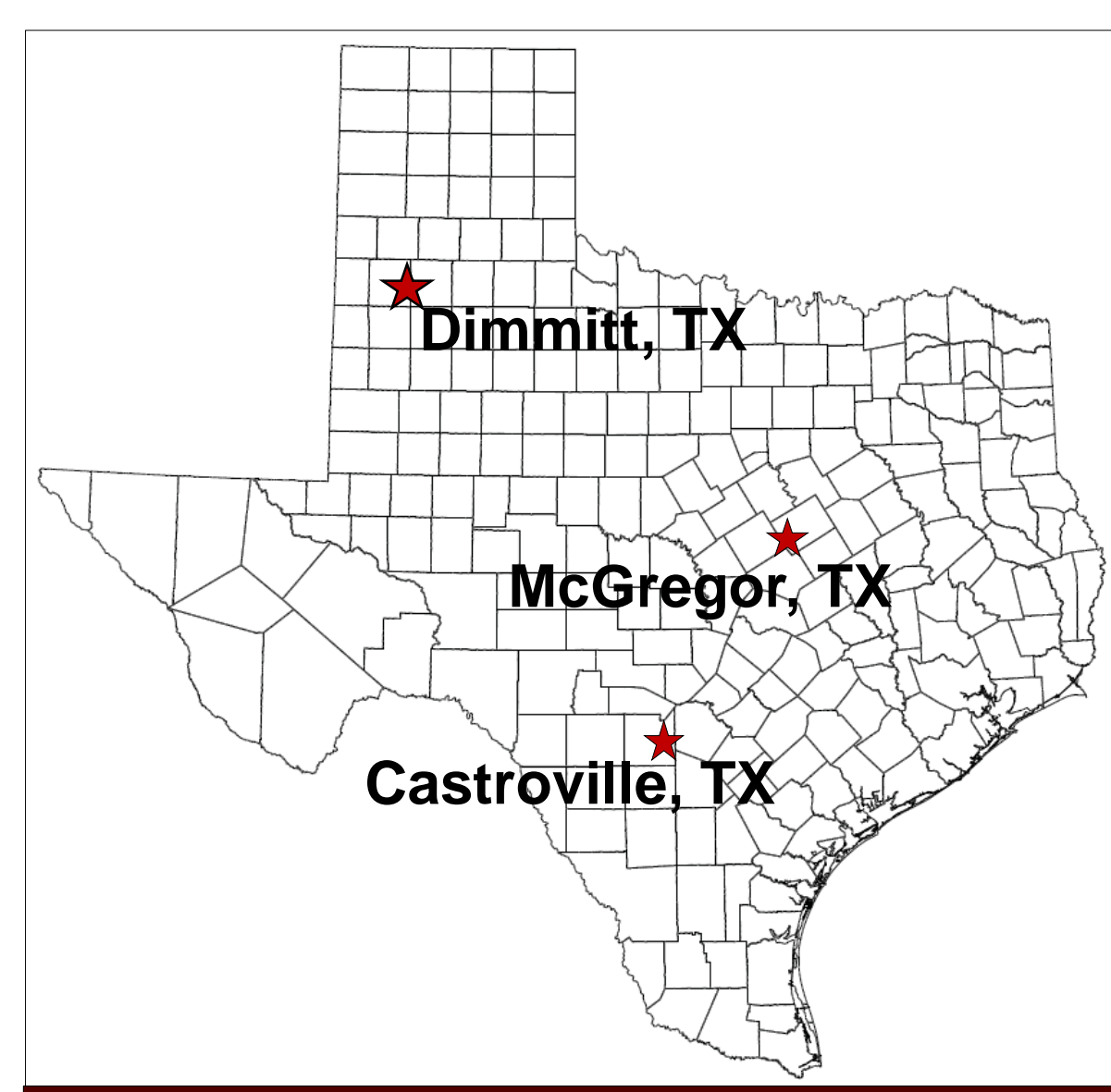


Figure 1. TCAP barley small plots in McGregor, TX.

Figure 2. TCAP barley evaluation locations.

## RESULTS

### Association of Malt Quality with Yield and Test Weight

- Winter lines yielded similarly across locations (MCG and CAS) and years in Central and South Texas; however overall malt quality of individual lines was not consistent across years at MCG (Fig. 3).
- Test weight was only moderately positively correlated to malt quality for winter and spring lines (Figs. 3, 4 and 5).
- 2-row and 6-row yields were moderately well correlated across years and locations.
- Malt quality of spring lines were closely correlated across years at MCG.

## RESULTS

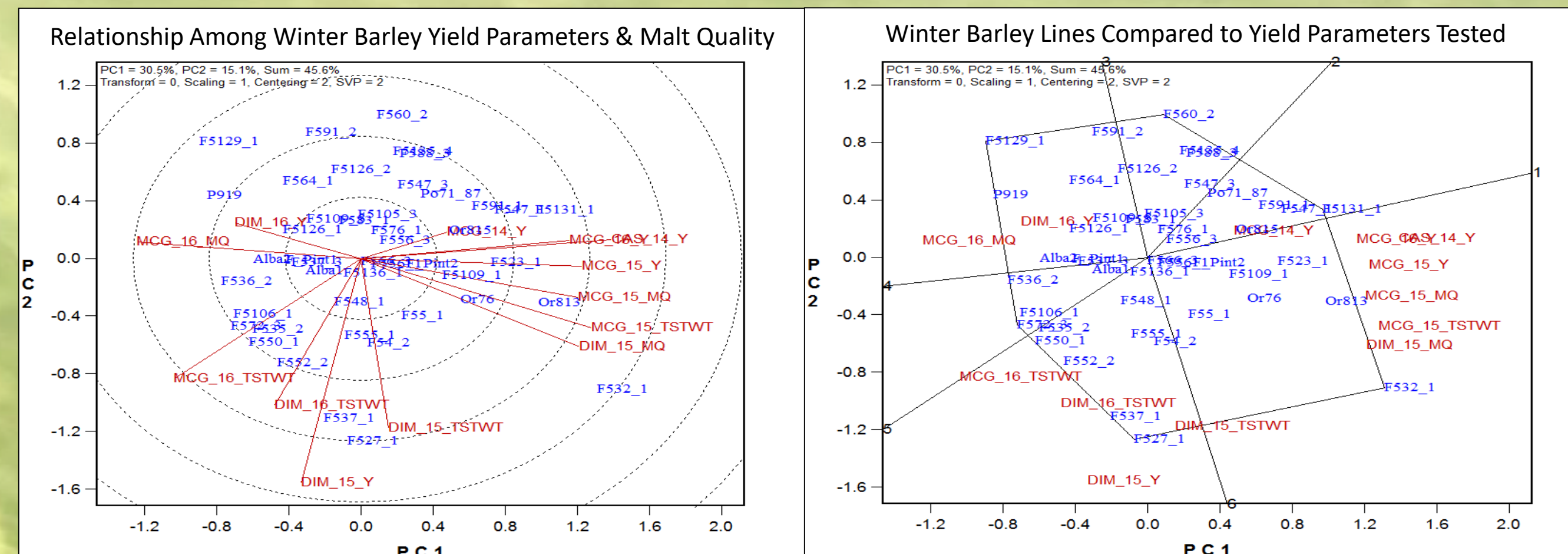


Figure 3. Biplot analysis comparing yield, test weight, and malt quality of TCAP winter barley lines across three years (2014-2016) and three locations (Castroville (CAS), McGregor (MCG), and Dimmitt (DIM), TX).

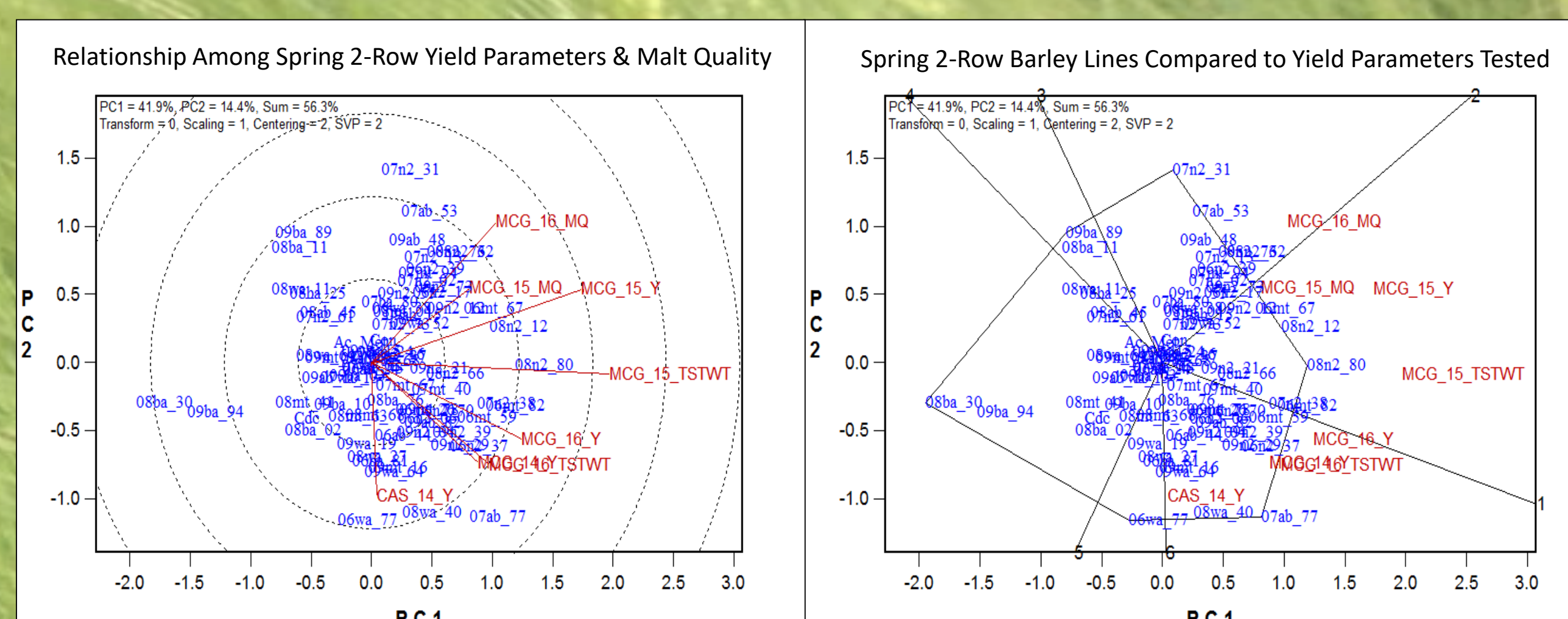


Figure 4. Biplot analysis comparing yield, test weight, and malt quality of TCAP spring 2-row barley lines across three years (2014-2016) and two locations (Castroville (CAS) and McGregor (MCG), TX).

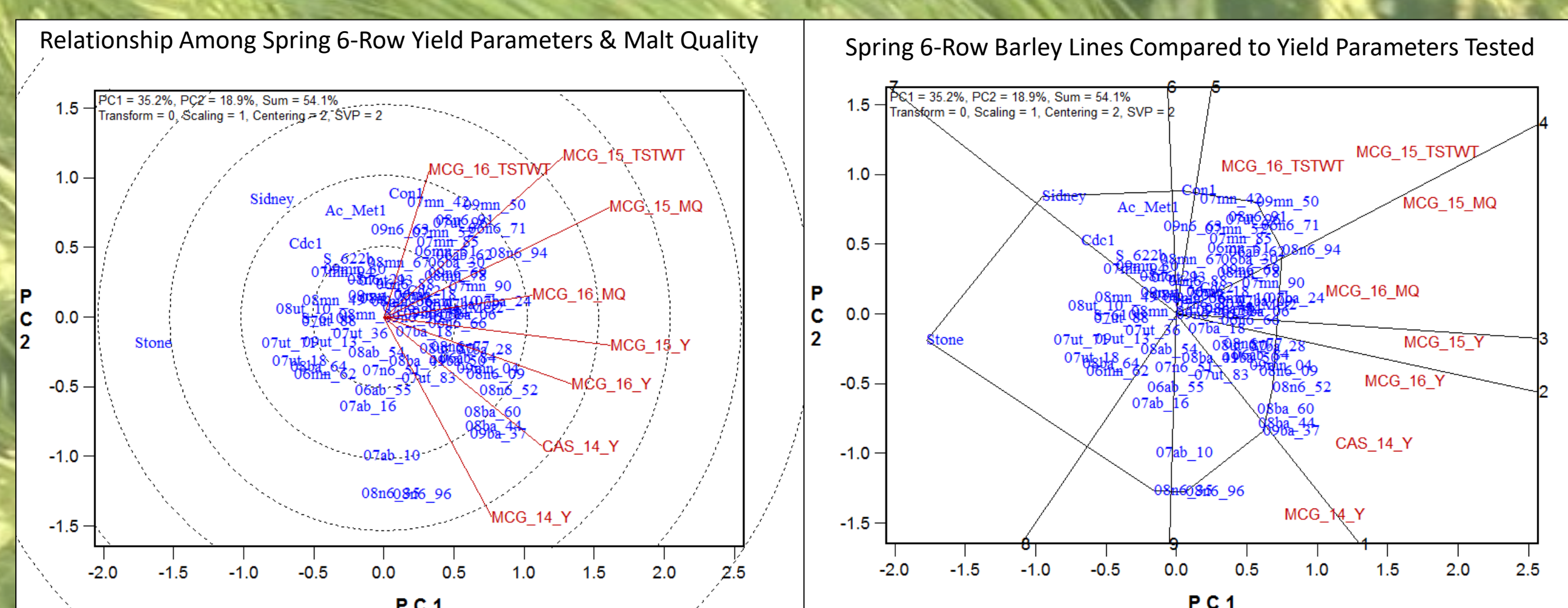


Figure 5. Biplot analysis comparing yield, test weight, and malt quality of TCAP spring 6-row barley lines across three years (2014-2016) and two locations (Castroville (CAS) and McGregor (MCG), TX).

Table 1. Summary of 2016 malt quality and yield data for DIM winter barley (A), MCG winter barley (B), MCG spring 2-row barley (C), and MCG spring 6-row barley.

A	Plump 6/64" (%)	Malt Extract (%)	Wort Clarity	Barley Protein (%)	Wort Protein (%)	ST (%)	DP (*ASBC)	α-amylase (20°DU)	β-glucan (ppm)	FAN (ppm)	Quality Score	Yield (kg/ha)
Entry (MSE)	187.2	4.3	0.3	1.3	0.5	35.6	1006	345	25364	2522	100	106087
Residual (MSE)	45.6	1.1	0.1	0.8	0.4	22.8	440	92	7551	898	33	81643
Mean	70.0	76.7	1.2	12.5	5.1	42.3	149	80	329	238	37	4702
Min	35.8	68.3	1.0	10.1	3.2	25.0	82	26	53	89	9	1837
Max	96.0	80.9	3.0	20.1	8.2	65.8	253	110	753	358	58	7915
LSD (0.05)	16.1	2.5	0.9	2.1	1.5	11.4	50	23	207	71	14	1762
CV	9.7	1.4	30.7	7.1	12.4	11.3	14.1	12.0	26.0	13.0	15.5	19.2
Significance	***	***	***	*	NS	**	**	***	***	***	***	*

B	Plump 6/64" (%)	Malt Extract (%)	Wort Clarity	Barley Protein (%)	Wort Protein (%)	ST (%)	DP (*ASBC)	α-amylase (20°DU)	β-glucan (ppm)	FAN (ppm)	Quality Score	Yield (kg/ha)
Entry (MSE)	104.9	4.1	0.6	0.9	0.3	21.2	1093	272	28375	2578	173	262451
Residual (MSE)	14.9	0.5	0.1	0.3	0.1	3.7	164	13	2276	233	31	86464
Mean	80.2	77.4	1.3	13.9	4.4	32.9	138	64	396	190	31	1181
Min	40.5	73.5	1.0	12.2	3.6	25.6	91	37	63	114	9	130
Max	92.4	81.0	3.0	16.4	5.5	44.5	246	99	674	303	63	2597
LSD (0.05)	7.5	1.3	0.7	1.1	0.4	3.7	25	7	93	30	11	617
CV	4.8	0.9	26.9	4.2	4.3	5.8	9.3	5.6	12.0	8.0	17.8	24.9
Significance	***	***	***	***	***	***	***	***	***	***	***	***

C	Plump 6/64" (%)	Malt Extract (%)	Wort Clarity	Barley Protein (%)	Wort Protein (%)	ST (%)	DP (*ASBC)	α-amylase (20°DU)	β-glucan (ppm)	FAN (ppm)	Quality Score	Yield (kg/ha)
Entry (MSE)	10.7	1.2	0.4	1.3	0.5	23.7	1060	473	72138	2772	59	405354
Residual (MSE)	7.6	0.7	0.2	0.6	0.3	23.4	160	106	25206	632	35	185753
Mean	96.6	81.6	1.3	11.0	5.1	48.5	128	79	331	237	50	2007
Min	83.2	78.4	1.0	9.1	3.9	35.9	66	44	47	150	28	445
Max	99.6	84.5	3.0	14.2	7.4	71.7	230	127	1625	357	70	3248
LSD (0.05)	6.5	2.0	1.1	1.7	1.2	11.3	29	24	372	59	14	906
CV	2.9	1.0	37.9	6.7	9.9	10.0	9.9	13.0	48.0	11.0	11.8	21.5
Significance	NS	*	*	**	*	NS	***	***	**	***	*	***

D	Plump 6/64" (%)	Malt Extract (%)	Wort Clarity	Barley Protein (%)	Wort Protein (%)	ST (%)	DP (*ASBC)	α-amylase (20°DU)	β-glucan (ppm)	FAN (ppm)	Quality Score	Yield (kg/ha)
Entry (MSE)	14.0	1.7	0.7	1.5	0.5	30.1	1849	235	18498	2186	87	186580
Residual (MSE)	9.8	0.7	0.4	0.6	0.3	23.6	587	110	5456	1271	43	76463
Mean	96.4	79.8	1.6	12.1	5.4	46.9	160	78	238	277	51	1607
Min	77.5	76.6	1.0	9.2	3.9	32.7	96	45	44	159	20	623
Max	99.5	82.5	3.0	14.9	7.4	63.1	309	123	572	366	70	2821
LSD (0.05)	7.3	2.0	1.5	1.8	1.3	11.3	56	24	172	83	15	571
CV	3.2	1.1	39.3	6.5	10.1	10.4	15.1	13.0	31.0	13.0	12.8	17.2
Significance	NS	**	*	**	NS	NS	**	**	**	*	*	***

## RESULTS

### Comparing Environments

#### Yield

- Yields of winter lines were closely correlated across years and locations in the Blacklands (MCG) and South Texas Plains (CAS).
- Yields of winter lines in the High Plains (DIM) in 2015 were not correlated with yields in 2016.
- Yields had either no correlation or a negative correlation between the High Plains and the Blacklands and South Texas Plains.
- In general, yield of spring 2-row and 6-row lines were moderately correlated across years and locations for the Blacklands and South Texas Plains.
- Winter lines yielded higher in DIM than MCG in 2016.
- On average, spring 2-row lines yielded the highest at MCG, followed by spring 6-row and then winter lines.

#### Malt Quality

- Malt quality of winter barley lines was highly positively correlated across locations in 2015.
- Malt quality of winter barley lines was highly negatively correlated across years at MCG (2015 had exceptionally high rainfall near harvest).
- Malt quality of spring 2-row and 6-row lines were each highly positively correlated across years at MCG.
- Average malt quality score of winter lines was slightly higher at DIM than MCG.
- Malt quality scores were comparable between 2-row and 6-row spring lines at MCG; however, spring types showed a distinct advantage over winter lines at this location.
- 2-row spring barley had slightly more desirable levels for malt extract, barley protein, diastatic power, and FAN than 6-rows. Winter lines performed worse in every category except alpha-amylase and FAN.
- Spring 6-row lines had the lowest beta-glucans on average. All barley types averaged above the acceptable beta-glucan level, but certain lines were below the specified threshold.

Table 2. List of top ranked barley TCAP lines and commercial cultivar checks for malt quality and their corresponding grain yield in 2016.

Name	Winter TCAP Lines			Spring 6-Row TCAP Lines			Spring 2-Row TCAP Lines			
	MCG Yield (kg/ha)	MCG Malt Quality	DIM Yield (kg/ha)	DIM Malt Quality	Name	MCG Yield (kg/ha)	MCG Malt Quality	Name	MCG Yield (kg/ha)	MCG Malt Quality
MW4118-4	2084	37	5295	56	07UT-71	1664	66	09N2-72	2785	70
MW4080-1	1684	39	4584	55	07BA-24	1761	63	08N2-12	2603	60
MW4118-1	2109	32	4118	53	08AB-54	1719	62	08N2-73	2076	60
MW4122-1	1567	45	3728	51	07BA-28	1782	62	08N2-62	2291	60
F5-5-1	1971	34	5432	48	09N6-69	1326	60	08N2-80	2659	59
Short 12	1065	41	5659	47	AC Metcalfe	1585	59	06MT-82	2863	56
F5-35-2	955	24	6682	42	06N6-71	1893	58	07N2-38	2699	55
MW4076-2	1958	36	4884	42	06N6-71	1893	58	AC Metcalfe	1818	51
Alba	1201	27	5273	41	08N6-77	2220	57	07MT-40	2900	51
F5-72-3	661	23	6057	41	08BA-60	1933	57	Conlon	1668	50
MW4116-4	2076	37	5051	41	08BA-60	1933	57	07WA-03	2669	49
OBA-13	1831	25	4906	40	09MN-04	2269	57	07WA-03	2669	49
08OR-48	1011	35	6034	39	OBA-54	1940	54	CDC Copeland	2021	47
F5-105-3	1183	22	6011	37	08N6-52	2361	54	09AB-82	2655	47
Full Pint	1406	28	5336	36	Conlon	1646	51	09N2-21	2707	46
07OR-6	897	50	4123	32	06AB-84	1987	48	08WA-40	2672	44
OR91	1000	53	4808	31	Stoneham	912	27	06WA-77	2578	37
Trial Mean	1181	31	4702	37	Trial Mean	1607	51	Trial Mean	2007	50

### Identifying Adapted Malt Barley Lines

- Certain TCAP barley lines out-yielded and outperformed commercial barley varieties for malt quality at both locations and for all three barley types.
- Lines that produced higher yields and malt quality than all commercial checks:
  - Winter: F5-5-1, MW4118-4
  - Spring 6-row: 07UT-71, 07BA-24, 08AB-54, 07BA-28
  - Spring 2-row: 09N2-72, 08N2-12, 08N2-73, 08N2-62, 08N2-80, 06MT-82, 07N2-38

## CONCLUSIONS

- Based on this preliminary data, the Texas High Plains appears to be a better environment to grow winter barley for malting than the Texas Blacklands.
- If growing malt barley in the Blacklands, spring 2-rows provided the highest yields and malt quality on average.
- A new cultivar release is possible from TCAP lines as many produced higher yields and better malt than commercially available cultivars grown in the trial under Texas environments.
- More site-years are needed to confirm superior lines for malt barley production before commercial release.

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