



FCDC Malting Barley Breeding Program

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Freedom To Create. Spirit To Achieve.

Field Crop Development Centre



Government of Alberta ■
Agriculture and Rural Development

Breeding Methodology

Creating Variability



Breeding Methodology

Return to Homozygosity

- Modified bulk breeding program
 - Each year from the F_2 up to F_5 or F_7 several thousand plants are grown from each cross
- Pressure put on bulks to move them in desired direction
 - By head selections in F_3 California nursery
 - By screening over gravity table in other generations

Spreading Scald Infected Straw



Head selections in California

Breeding Methodology

Head Selection



- Head selections, 100 to 200 from each cross or population of about 8,000 plants OR a 2% selection rate.
 - Based on disease resistance, plant and head type only.

Breeding Methodology

Yield and quality evaluations



- Selected heads are grown out as F_6 - F_8 headrows
 - Approx. 5% selected
- Selected rows are advanced to yield tests
 - 1st year non-replicated
 - 2nd to 5th year multi-location replicated tests
 - Approx. 20% selected

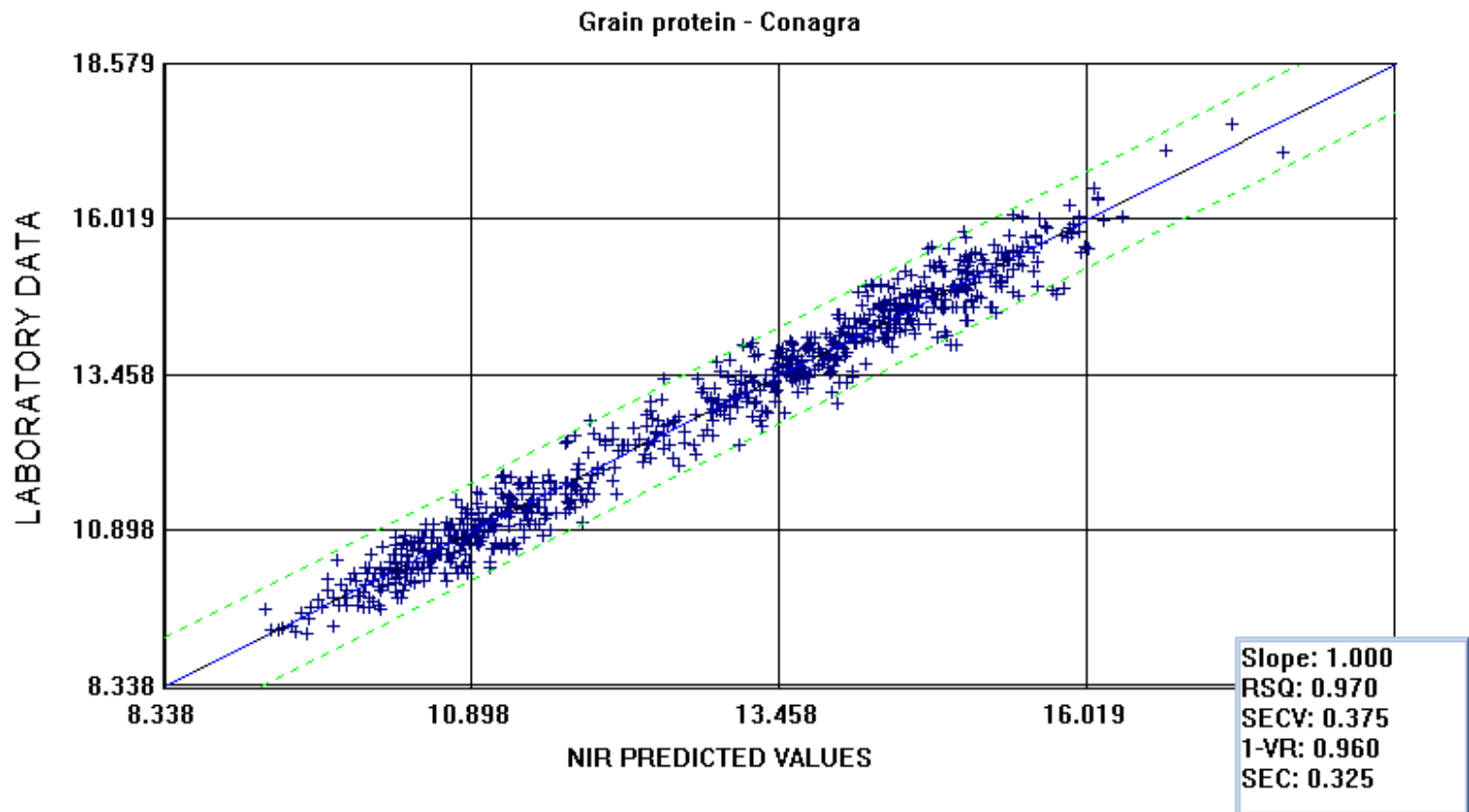
Selection for malting quality in barley using NIRS



Quality Assessment using NIRS Foss 6500



Barley Grain Protein – Canada Malting



Oatway, L. and J.H. Helm. 2007. Development of robust near infrared reflectance spectroscopy (NIRS) calibrations using genetic and environmental variation. 5th Canadian Barley Symposium. Winnipeg, MB.

Quality Assessment

- Food quality (grain)
 - Soluble fibre: pentosans, beta-glucans
- Feed quality (grain)
 - Protein
 - Starch
 - Protein digestibility (pig)
 - Energy content (pig)
- Malting quality
 - Malt extract
 - Malt protein: total, soluble
 - Enzyme activity: Diastatic Power, Alpha Amylase
 - Beta-glucan, viscosity
 - Friability, homogeneity, turbidity

Quality Assessment of Bentley and its sister lines in 2000 (non-replicated, one location)

| Line | Protein | FE | DP | AA | Total Protein | Soluble Protein | S/T ratio | Beta-glucan | Friability | Homogeneity | Turbidity | Viscosity |
|------------|---------|------|-----|------|---------------|-----------------|-----------|-------------|------------|-------------|-----------|-----------|
| H930103001 | 10.2 | 82.9 | 124 | 55.3 | 9.7 | 6.0 | 62 | 79 | 79 | 99 | 3.64 | 1.49 |
| H930103002 | 10.7 | 82.9 | 118 | 53.3 | 10.1 | 5.6 | 55 | 113 | 75 | 96 | 4.26 | 1.50 |
| H930103003 | 12.7 | 80.7 | 133 | 48.8 | 12.2 | 5.4 | 44 | 502 | 50 | 86 | 3.44 | 1.58 |
| Bentley | 12.5 | 81.5 | 124 | 49.6 | 12.0 | 6.1 | 51 | 258 | 58 | 88 | 2.59 | 1.53 |
| H930103005 | 12.9 | 80.6 | 144 | 51.0 | 12.4 | 6.4 | 52 | 299 | 57 | 90 | 3.99 | 1.52 |
| H930103006 | 11.5 | 81.2 | 116 | 49.3 | 11.2 | 6.0 | 54 | 200 | 63 | 92 | 4.04 | 1.46 |
| H930103007 | 12.4 | 81.2 | 140 | 51.1 | 12.1 | 6.2 | 51 | 257 | 57 | 89 | 0.55 | 1.46 |
| H930103008 | 12.6 | 80.9 | 141 | 52.7 | 12.2 | 6.4 | 52 | 397 | 49 | 86 | 0.46 | 1.53 |
| H930103009 | 11.2 | 82.0 | 138 | 56.0 | 10.9 | 6.9 | 63 | 139 | 66 | 95 | 1.60 | 1.43 |
| Harrington | 13.0 | 79.5 | 134 | 54.3 | 12.5 | 6.7 | 54 | 541 | 50 | 85 | 1.71 | 1.52 |

NIRS predicted Malting Quality for Bentley and its sister lines from 2001 Lacombe and Trochu

NIRS Predicted Malting quality for H93103 sister lines from the 2001 Lacombe and Trochu

| | Protein % | Fine Extract | DP | AA | Total Protein (Malt) | Soluble Protein (Malt) | ST ratio | B-Glucan (Malt) | Friability (Malt) | Viscosity | Homogeneity | Turbidity |
|----------------|-----------|--------------|-----|------|----------------------|------------------------|----------|-----------------|-------------------|-----------|-------------|-----------|
| Lacombe | | | | | | | | | | | | |
| H93103002Y | 12.6 | 79.9 | 161 | 52.8 | 12.1 | 4.6 | 38 | 376 | 49 | 1.55 | 84.1 | 3.6 |
| H93103003Y | 13.4 | 78.6 | 164 | 49.8 | 13.1 | 4.8 | 36 | 364 | 42 | 1.58 | 82.3 | 4.5 |
| Bentley | 13.0 | 78.7 | 165 | 52.4 | 12.7 | 4.6 | 36 | 383 | 42 | 1.58 | 84.0 | 4.1 |
| AC Metcalfe | 13.9 | 79.2 | 182 | 59.6 | 13.3 | 5.4 | 41 | 322 | 46 | 1.54 | 86.5 | 4.1 |
| Harrington | 13.4 | 79.0 | 172 | 61.7 | 13.1 | 5.6 | 43 | 428 | 48 | 1.57 | 83.7 | 3.8 |
| Trochu | | | | | | | | | | | | |
| H93103002Y | 11.9 | 80.0 | 125 | 58.5 | 11.2 | 5.8 | 51 | 289 | 48 | 1.57 | 89.1 | 3.6 |
| H93103003Y | 12.7 | 78.6 | 138 | 52.1 | 12.3 | 5.2 | 43 | 308 | 43 | 1.63 | 86.5 | 3.6 |
| Bentley | 11.8 | 80.4 | 136 | 54.4 | 11.2 | 5.5 | 50 | 78 | 43 | 1.61 | 90.0 | 3.3 |
| AC Metcalfe | 11.9 | 81.1 | 156 | 57.6 | 11.3 | 5.5 | 48 | 162 | 50 | 1.60 | 93.3 | 2.9 |
| Harrington | 11.7 | 81.4 | 143 | 69.7 | 10.8 | 6.1 | 56 | 248 | 59 | 1.56 | 92.0 | 2.2 |

NIRS Predicted Quality for H93103 sister lines from 2002 Lacombe and Trochu

NIRS predicted quality for H93103 sister lines from the 2002 Lacombe and Trochu yield to

| | Protein | Fine Extract | DP | AA | Total Protein | Soluble Protein | ST Ratio | B-Glucan | Friability | Viscosity | Homogeneity | Turbidity | Potential Skinning |
|----------------|---------|--------------|-----|------|---------------|-----------------|----------|----------|------------|-----------|-------------|-----------|--------------------|
| Lacombe | | | | | | | | | | | | | |
| H93103002 | 12.6 | 78.9 | 169 | 33.6 | 15.2 | 4.9 | 32 | 342 | 53.3 | 1.50 | 81.9 | 5.44 | 55 |
| Bentley | 12.6 | 78.9 | 170 | 33.2 | 15.2 | 5.3 | 35 | 102 | 48.2 | 1.47 | 80.1 | 4.88 | 43 |
| Harrington | 13.3 | 78.4 | 169 | 37.3 | 16.1 | 5.4 | 34 | 241 | 49.9 | 1.53 | 80.5 | 4.97 | 50 |
| AC Metcalfe | 13.2 | 78.7 | 182 | 34.1 | 15.9 | 5.3 | 33 | 184 | 53.2 | 1.49 | 83.7 | 4.80 | 53 |
| Trochu | | | | | | | | | | | | | |
| H93103002 | 11.4 | 79.0 | 148 | 32.2 | 13.4 | 3.1 | 23 | 418 | 60.5 | 1.52 | 83.8 | 4.88 | 63 |
| Bentley | 11.4 | 79.5 | 157 | 37.0 | 13.9 | 4.1 | 29 | 279 | 57.4 | 1.51 | 82.4 | 4.07 | 48 |
| Harrington | 12.7 | 78.7 | 161 | 41.9 | 15.5 | 5.3 | 34 | 284 | 49.6 | 1.54 | 80.1 | 3.71 | 50 |
| AC Metcalfe | 12.4 | 79.0 | 176 | 39.9 | 14.9 | 4.8 | 32 | 265 | 51.1 | 1.53 | 84.5 | 3.48 | 56 |

Wet chemistry for H9103 sister lines from Trochu and Calmar in 2003

Wet chemistry by Canada Malting Co. for H93103 sister lines from the Trochu and Calmar yield trials in 2003.

| | % | As Is | Ext | | Total | Sol. | | Visc | | | | Wort |
|----------------------|-------|---------|------|--------|-------|-------|-----|-------|--------|-----|------|-------|
| Sample | Prot. | Extract | Db | Colour | Prot. | Prot. | S/T | osity | Friab. | DP | AA | B-Glu |
| <i>Trochu</i> | | | | | | | | | | | | |
| H93103002 | 13.6 | 76.0 | 79.4 | 1.28 | 13.5 | 4.8 | 36 | 1.89 | 47.1 | 141 | 56.3 | 841 |
| Bentley | 12.7 | 76.9 | 80.6 | 1.11 | 13.0 | 4.8 | 37 | 1.71 | 51.8 | 135 | 52.8 | 651 |
| Harrington | 13.7 | 76.0 | 79.5 | 1.27 | 13.6 | 5.3 | 39 | 1.70 | 52.0 | 143 | 56.7 | 655 |
| AC Metcalfe | 13.4 | 76.6 | 80.3 | 1.28 | 13.5 | 4.8 | 35 | 1.62 | 44.1 | 144 | 59.7 | 478 |
| <i>Calmar</i> | | | | | | | | | | | | |
| H93103002 | 8.7 | 79.2 | 83.6 | 1.72 | 8.5 | 4.5 | 43 | 1.49 | 89.4 | 84 | 39.8 | 97 |
| Bentley | 9.2 | 80.3 | 83.3 | 1.32 | 9.0 | 4.0 | 45 | 1.53 | 86.9 | 76 | 43.5 | 256 |
| Harrington | 9.1 | 79.6 | 82.9 | 1.21 | 8.7 | 3.9 | 45 | 1.71 | 83.0 | 87 | 50.9 | 492 |
| AC Metcalfe | 9.3 | 79.8 | 83.4 | 1.51 | 8.8 | 4.3 | 49 | 1.49 | 91.9 | 96 | 54.1 | 101 |

Micro-malting quality for Bentley in 2005 and 2006 Coops

Malting quality data as presented in the 2005 and 2006 Western Cooperative Two Row Barley Registration Tables

| | | 1000.0 | | | Soluble | S/T | Diast. | Alpha- | Beta- | | | |
|----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|-----------|-------------|-------------|------------|
| | Plump | K. Wt. | Protein | F. Ext. | Protein | Ratio | Power | Amylase | Glucan | Viscos. | Friab | Peeled |
| | % | G. | % | % | % | % | °L | D.U. | ppm | cps | % | % |
| MEAN of Six Station Years | | | | | | | | | | | | |
| Bentley | 93.4 | 48.4 | 11.7 | 80.0 | 4.79 | 40.4 | 107 | 55.6 | 95 | 1.43 | 88.7 | 6.3 |
| Harrington | 89.2 | 42.9 | 11.9 | 79.7 | 4.92 | 41.3 | 115 | 56.8 | 111 | 1.45 | 90.0 | 9.4 |
| AC Metcalfe | 91.7 | 44.3 | 12.1 | 80.2 | 4.92 | 40.5 | 132 | 60.6 | 62 | 1.43 | 85.7 | 6.5 |
| CDC Kendall | 93.2 | 43.1 | 12.2 | 80.0 | 5.01 | 40.6 | 152 | 61.0 | 53 | 1.42 | 92.0 | 4.5 |

Micro-malting results from the 2006 and 2007 Collaborative tests

Malting quality data as presented in the 2007 Western Collaborative report.

| | Plump | Protein | Barley P&B | Malt P&B | F. Ext. | Malt Protein | Soluble Protein | S/T Ratio | Diast. Power | Alpha- Amylase | Beta- Glucan | Viscosity | Friability |
|-------------------------------------|-------|---------|---------------|-------------|---------|-----------------|--------------------|--------------|-----------------|-------------------|-----------------|-----------|------------|
| | % | % | % | % | % | % | % | % | °L | D.U. | ppm | % | % |
| 2006-2007 Mean | | | | | | | | | | | | | |
| AC Metcalfe | 94.8 | 12.3 | 3.2 | 7.7 | 80.8 | 11.8 | 5.04 | 43.0 | 153 | 65.9 | 175 | 1.47 | 79.6 |
| Bentley | 96.8 | 11.3 | 3.5 | 9.1 | 81.7 | 10.8 | 4.90 | 45.7 | 122 | 57.7 | 162 | 1.48 | 75.6 |
| 2006-2007 Standard Deviation | | | | | | | | | | | | | |
| AC Metcalfe | 3.3 | 0.8 | 3.6 | 7.2 | 1.2 | 1.0 | 0.40 | 3.5 | 21 | 11.7 | 117 | 0.08 | 9.2 |
| Bentley | 1.3 | 1.0 | 2.9 | 8.7 | 0.8 | 0.9 | 0.46 | 4.3 | 19 | 14.2 | 96 | 0.12 | 11.9 |

H93103004 (TR05669) Registered as Bentley Two-Row Malting Barley



- Cross of a ND line (with Harrington and Bowman in its parentage) and TR229 (a Brandon line with AC Oxbow and Manley in its parentage) made in 1993
- Developed using traditional modified bulk breeding method
- Promoted due to malting quality combined with excellent yields and disease resistance

Summary

- NIRS can be used as an early generation screening tool to select for malting quality traits
- Our NIRS quality calibrations tend to predict high for malt beta-glucan, diastatic power and alpha-amylase, but are good for protein, extract, viscosity, homogeneity, turbidity
- Currently working on upgrading the malting quality calibrations with integration of Michael Edney's GRL malting quality from the John O'Donovan led project "Improvement of Malt Barley Quality and Seed Homogeneity through Optimization of Agronomic, Genetic, and Environmental Factors"

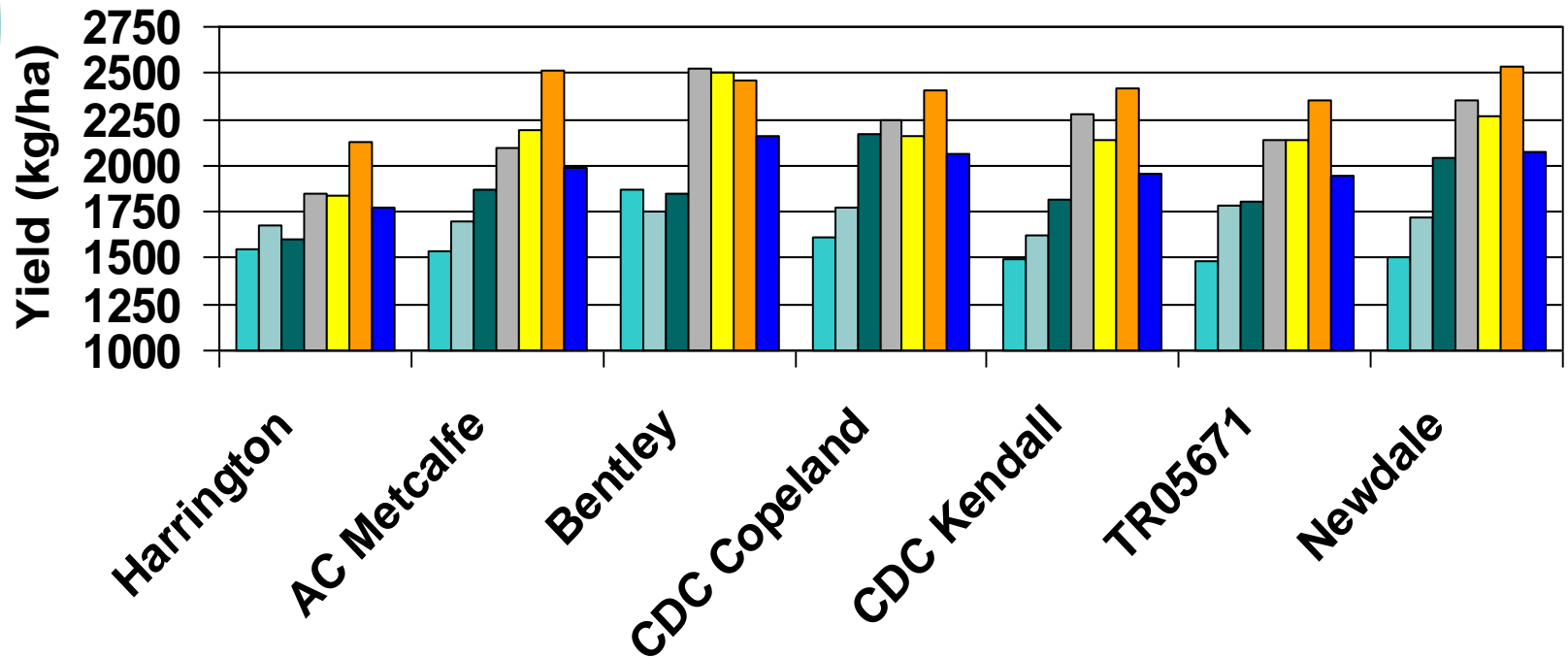
The Future

- Our needs:
 - to update calibrations
 - add new calibrations ie limit dextranase, FAN
 - Micro-Malting capacity for late generation material





2007 Yield data for malting varieties



Lacombe Low Fert

Morrin

Lacombe Late Seed

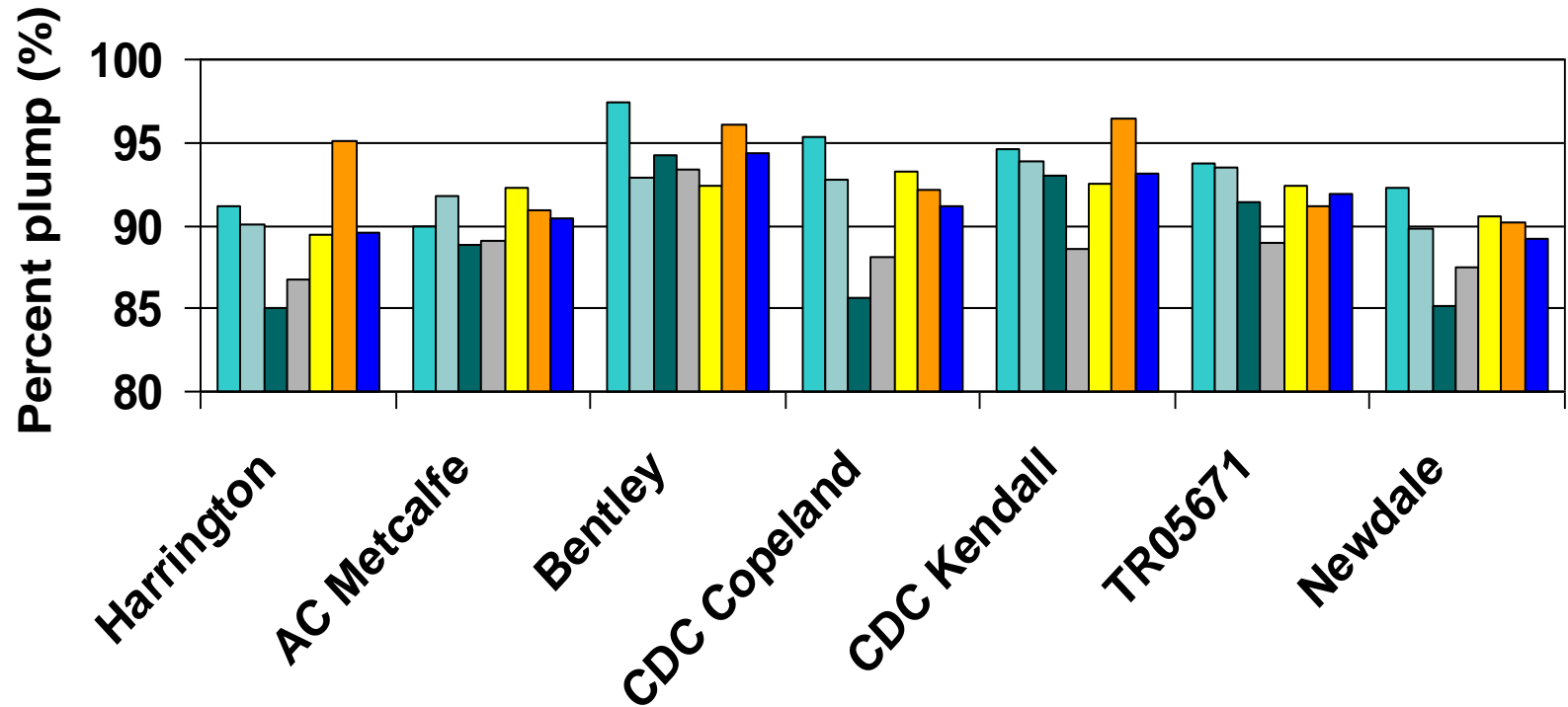
Lacombe Hi Fert

Calmar

Olds

Average

2007 Plump for malting varieties



Lacombe Low Fert

Morrin

Lacombe Late Seed

Lacombe Hi Fert

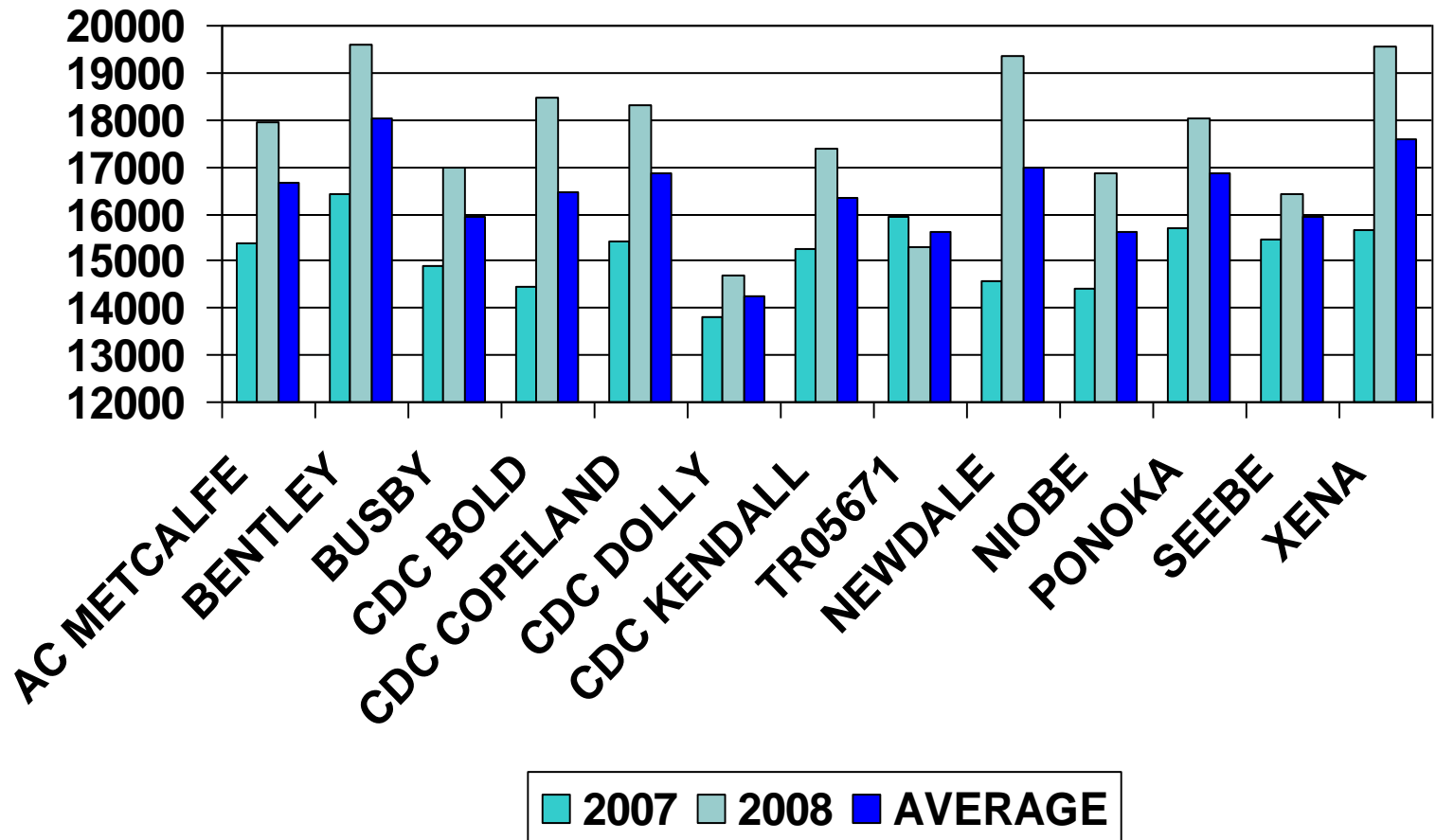
Calmar

Olds

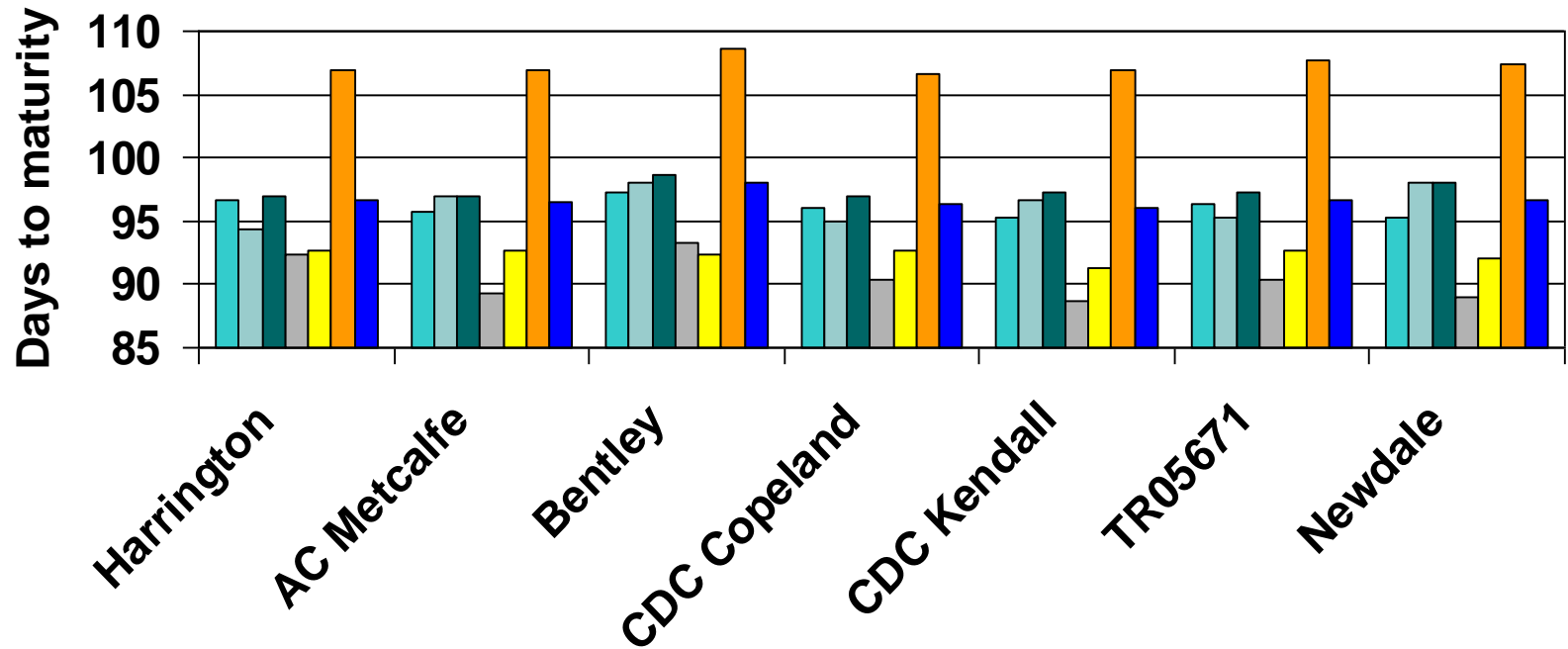
Average

Dry matter yields at Lacombe for 2007 and 2008

DM Biomass Yield (kg/ha)



2007 Maturity of malting varieties



Lacombe Low Fert

Morrin

Lacombe Late Seed

Lacombe Hi Fert

Calmar

Olds

Average



Bentley Two-Row Malting Barley

- 11% higher yielding than AC Metcalfe
- Similar maturity to Xena (1-2 days later than AC Metcalfe)
- Tall, but lodging resistance similar to Xena
- High test weight, kernel weight and percent plump
- 8% higher biomass yields than Virden, the six-row Coop check cultivar

Bentley Two-Row Malting Barley

- Disease resistance:
 - R to net blotch (spot), MR to spot blotch
 - MR to surface borne smuts, MS to loose smut
 - MR/MS to FHB, Stem rust, and common root rot
 - S to net blotch (net), scald, septoria, and BYD