Update of WSU Barley Breeding Program

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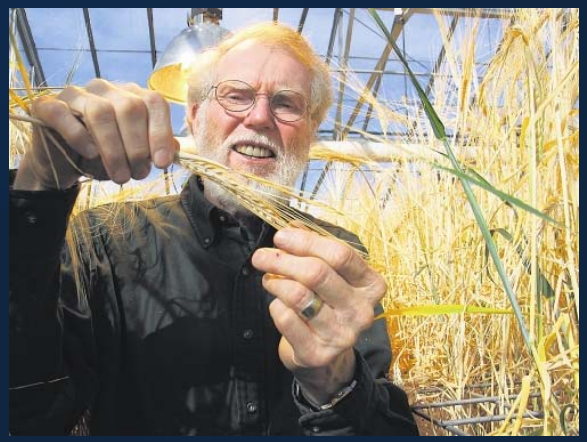
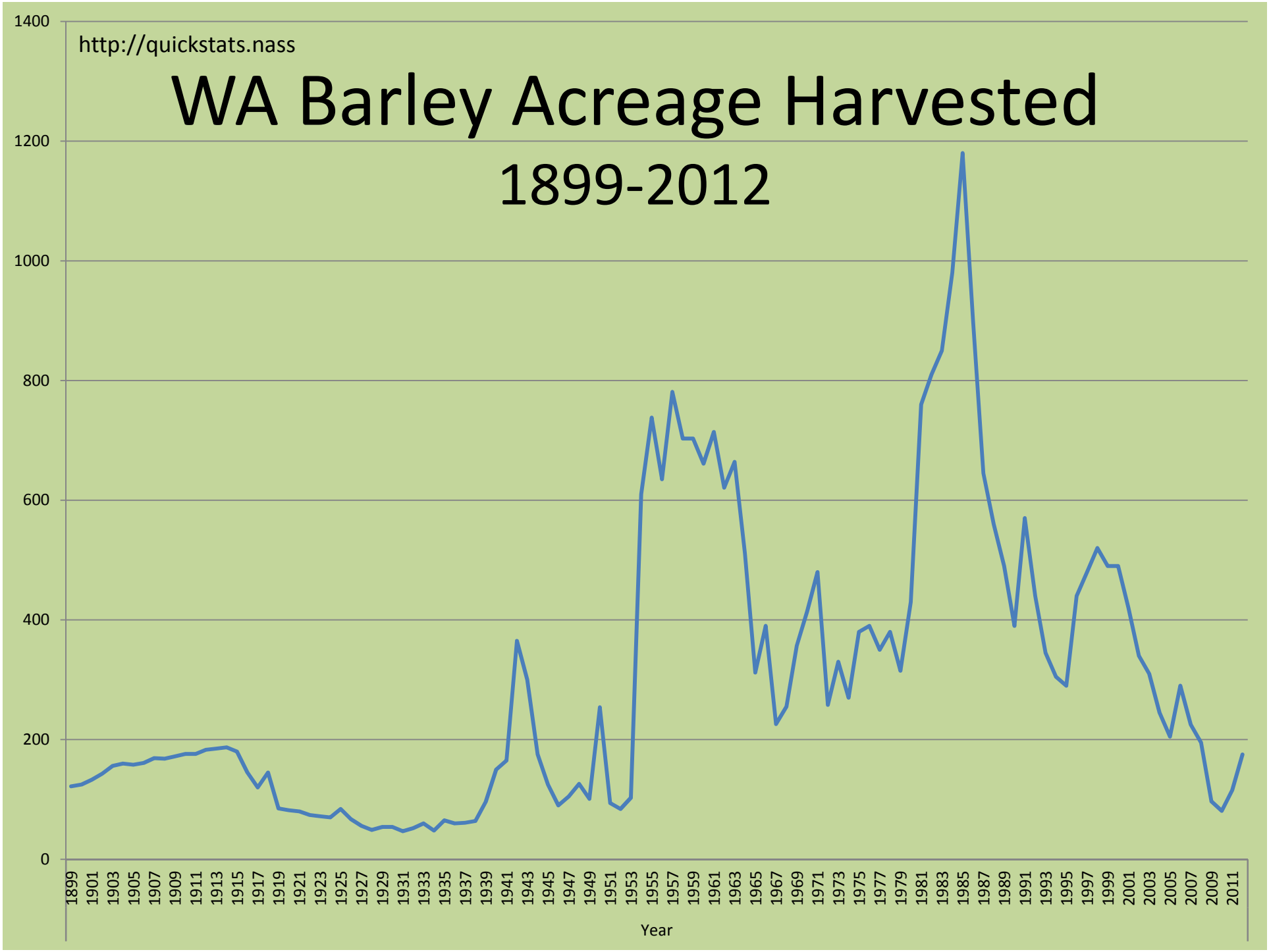
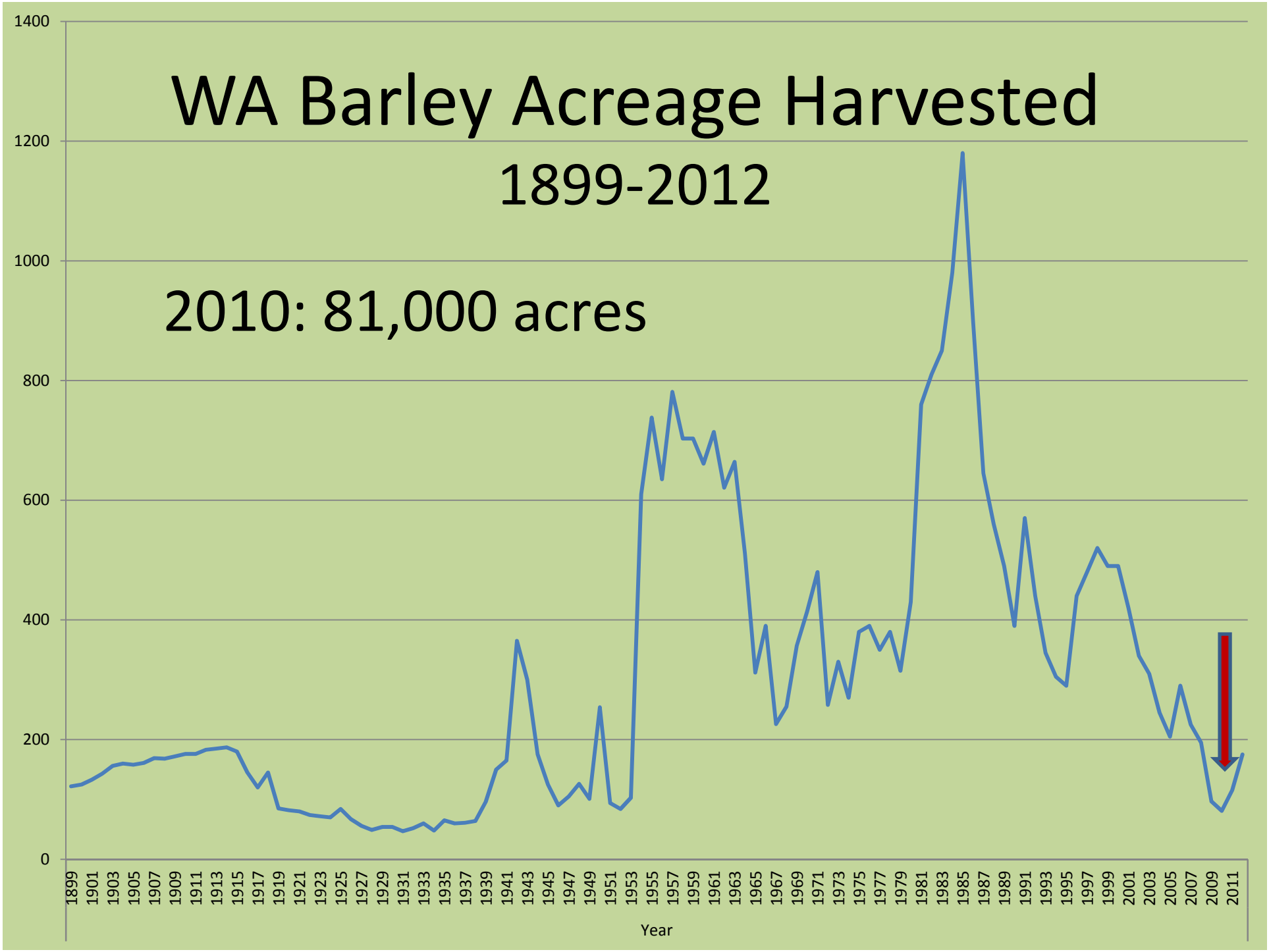
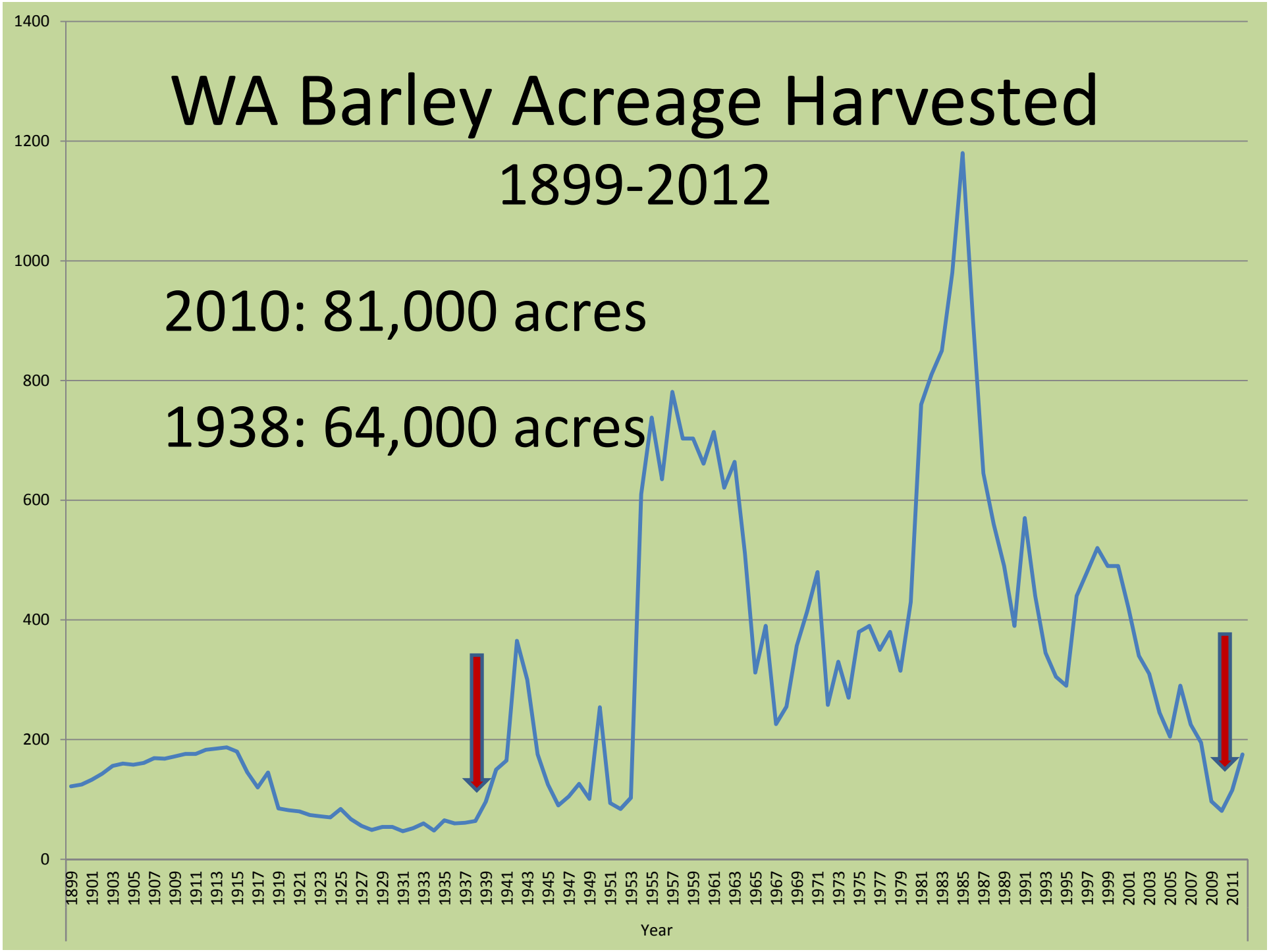
WSU Collaborators: S. Guy, X. Chen, S. Rustgi, B.-K. Baik, I. Burke, D. See, D. von Wettstein

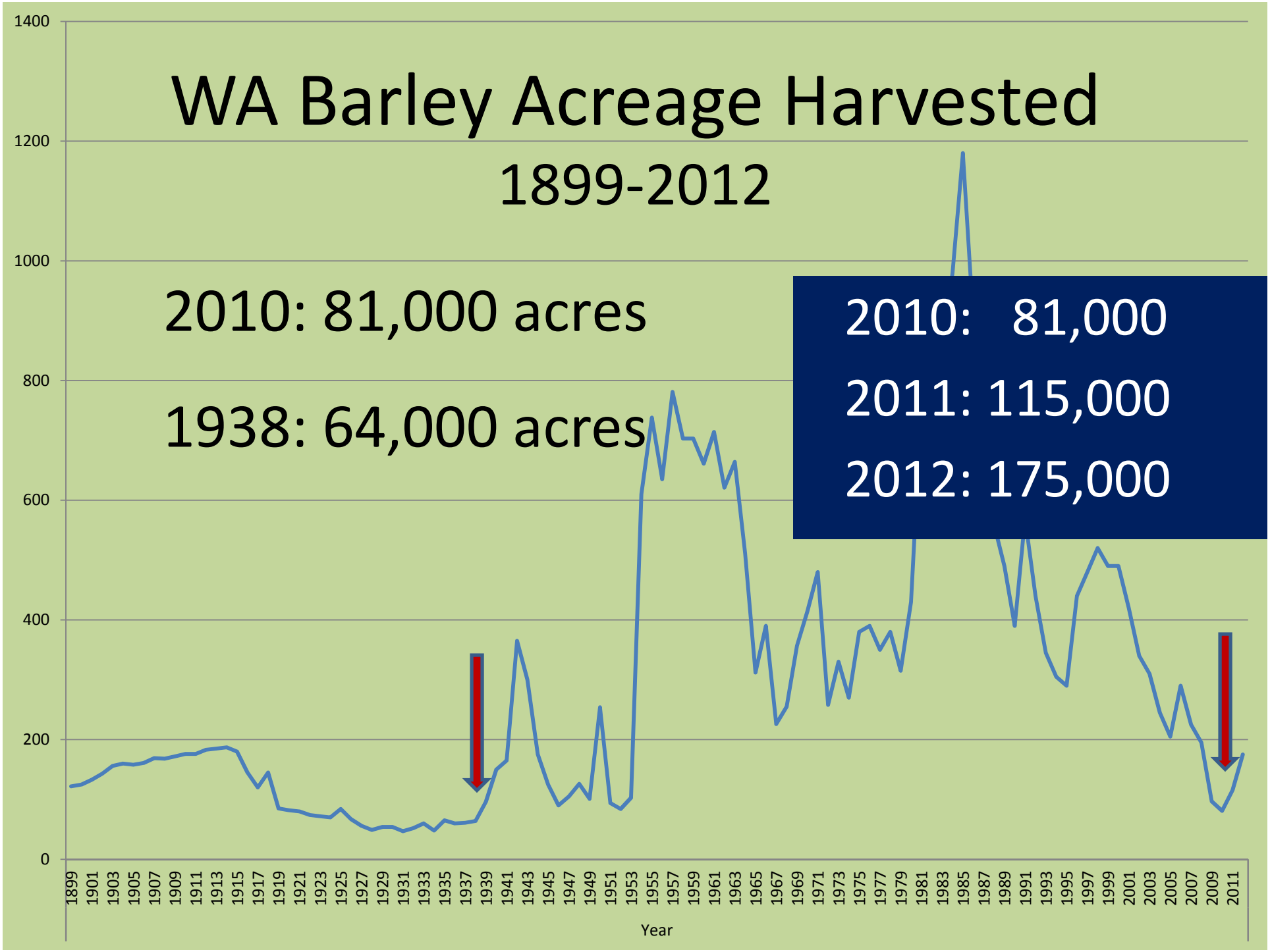
Collaborators: K. Smith, P. Hayes




http://quickstats.nass
WA Barley Acreage Harvested
1899-2012
1400
1200
1000
800
600
400
200
0
1899 1901 1903 1905 1907 1909 1911 1913 1915 1917 1919 1921 1923 1925 1927 1929 1931 1933 1935 1937 1939 1941 1943 1945 1947 1949 1951 1953 1955 1957 1959 1961 1963 1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011
Year


WA Barley Acreage Harvested
1899-2012
2010: 81,000 acres
1400
1200
1000
800
600
400
200
0
1899 1901 1903 1905 1907 1909 1911 1913 1915 1917 1919 1921 1923 1925 1927 1929 1931 1933 1935 1937 1939 1941 1943 1945 1947 1949 1951 1953 1955 1957 1959 1961 1963 1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011
Year


WA Barley Acreage Harvested
1899-2012
2010: 81,000 acres
1938: 64,000 acres
1400
1200
1000
800
600
400
200
0
Year


WA Barley Acreage Harvested
1899-2012
2010: 81,000 acres
1938: 64,000 acres
2010: 81,000
2011: 115,000
2012: 175,000
1400
1200
1000
800
600
400
200
0
Year

Areas of Focus

- **Malting Barley**
- Hulless / Food & Feed Barley
- Feed Breeding Lines for Pre-Release
- Herbicide Tolerant Barley

Malting Barley

- ~10% of Washington Barley is for malting
- AMBA has not recommended a Washington variety since the early 1980's
- Lack of prioritization on breeding for malting varieties
- Great Western Malting

Malting barley

- Renewed emphasis on malting
- Many new crosses / early generation lines
  - Early generation malting quality
- Advanced yield trials dedicated to malting
- SNP based marker assisted selection

Marker Assisted Selection

- 48 BOPA_C marker names based on the Oregon Wolfe Barley mapping population
- These SNP markers flank QTL associated with malting traits
- 192 advanced lines

Lines	WELL	11_10048	11_10084	11_10183	11_10185	11_11094	11_11136	11_11277	11_11367	11_11497	11_20103	11_20180	11_20383
08WA-107.11	A04	G	C	C		G		G	G		G	C	C
08WA-107.8	A02	G	C	C					G		G		
08WA-109.11	A06	G	C	C	G	G	C	G	G	T	G	C	C
08WA-109.16	A08	G	C	C	G	G	C	G	G	T	G	C	C
08WA-109.17	A10	G	C	C	G	G	C	G	G	T	G	C	C
08WA-111.3	A12	G	A	C	G	G	C	G	G	T	G	C	C
08WA-112.6	A14	G	C	C					G		G		
08WA-112.7	A16		C	C	G	G	C	G	G	T	G	C	C
08WA-118.12	A20	G	C	C	G	G	C	G	G	T	G	C	C
08WA-118.4	A18				G	G	C	G		T		C	C
08WA-138.8	A22	G	C	C	G	G	C	G	G	T	G	C	C
08WA-138.9	A24	G	C		G	G	C	G	G	T		C	C
08WA-142.22	C02	G	C	C					G		G		C
08WA-142.24	C04	G	C	C	G	G	C	G	G	T	G	C	C
09WA-206.17	C10	G	C	C	G	A	C	G	G	T	G	C	C
09WA-206.29	C12		C	C	AG	G	C	G	G	GT	G	C	C

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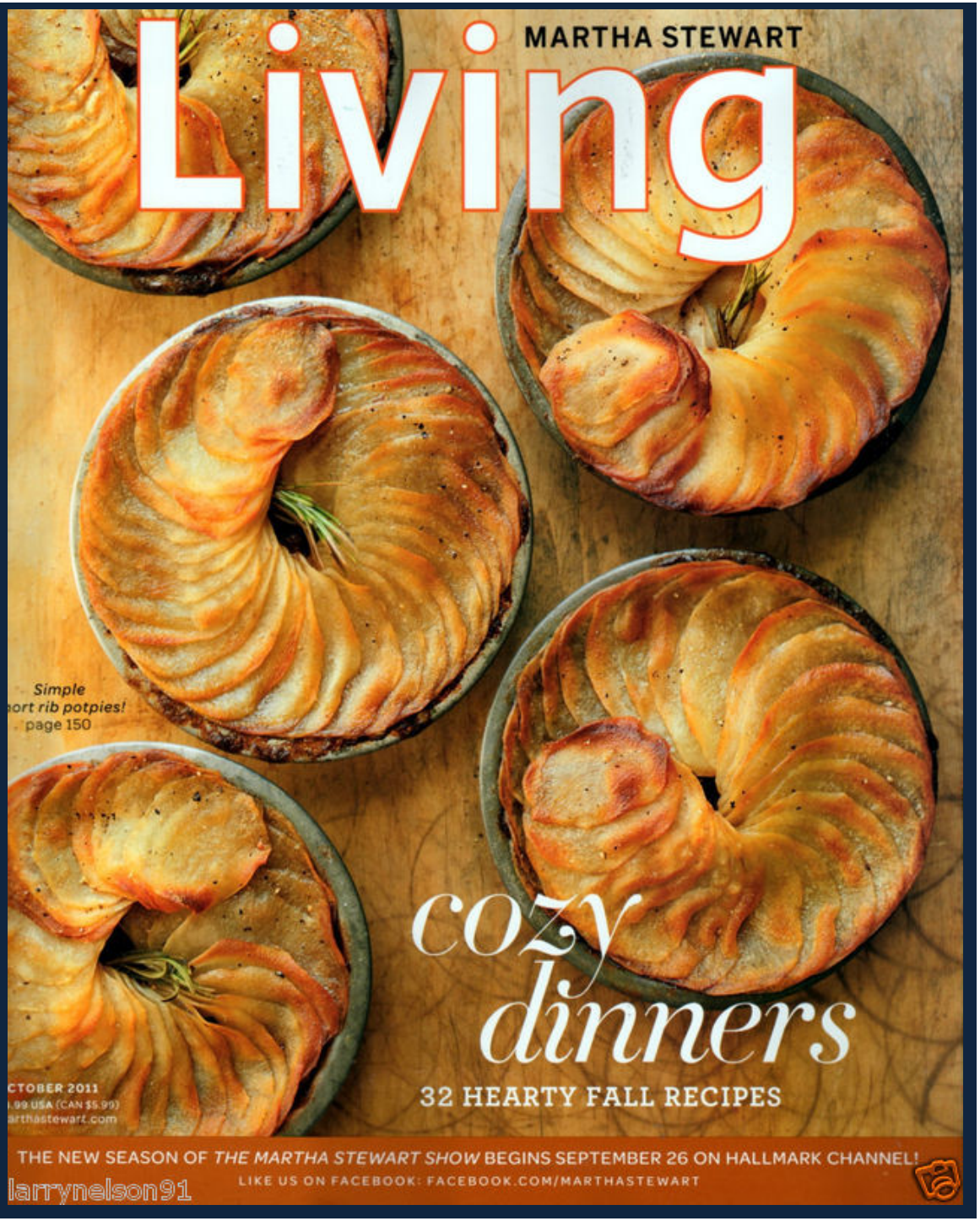
Barley Nutrition



Hulless Barley – Variety Testing 16-20” (5 locations)

Variety / Breeding Line	Yield (Lbs/A)	Test Weight (Lbs/Bu)	Protein %	Yield Increase %
X05056-T211	3390	60.2	14.0	9%
Meresse	3110	60.9	14.9	x
Lsd (P=0.10)	140	0.4	0.3	

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Meresse	3110	60.9	14.9	x
Champion	4220	54.9	11.4	36%
Lsd (P=0.10)	140	0.4	0.3	

Hulless Barley – Variety Testing >20” (3 locations)

Variety / Breeding Line	Yield (Lbs/A)	Test Weight (Lbs/Bu)	Protein %	Yield Increase %
X05056-T211	3240	59.6	13.9	13%
Meresse	2880	58.4	15.2	x
Lsd (P=010)	250	0.5	0.5	

Hulless Barley – Variety Testing >20” (3 locations)

Variety / Breeding Line	Yield (Lbs/A)	Test Weight (Lbs/Bu)	Protein %	Yield Increase %
X05056-T211	3240	59.6	13.9	13%
Meresse	2880	58.4	15.2	x
Champion	4180	53.8	11.3	45%
Lsd (P=010)	250	0.5	0.5	

Hulless Barley – Pullman 2012 PSUN

Variety / Breeding Line	Yield (Lbs/A)	Test Weight (Lbs/Bu)	Protein %
Champion	5211	53.3	10.7
Bob	5216	54.4	9.4
Baronesse	5115	52.7	9.5
X06G07-T43	5051	**56.6**	**12.1**
X05013-T1	4968	**61.4**	11.2
X07G19-T270	4963	**60.7**	11.3
Lsd (P<0.10)	***395***	***1.3***	***0.9***

All hulless lines ranked higher than Meresse and Clearwater

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- **Feed Breeding Lines for Pre-Release**
- Herbicide Tolerant Barley

Candidates for Pre-Release

- Goal – beat Champion, Lenetah, Bob and Baronesse
- High Rainfall – 2 candidate lines
  - Top yielder in no-till trials
- Low Rainfall – 1 candidate line
  - Also highest yielding in lower-input / organic nurseries
  - Excellent stem rust resistance

Areas of Focus

- Malting Barley
- Hulless / Food & Feed Barley
- Feed Breeding Lines for Pre-Release
- **Herbicide Tolerant Barley**
  - **>300,000 acres of Clearfield WW grown in WA**
  - **Need barley varieties that can hold up in soils with residual herbicide**

Herbicide Tolerance

- Imi-tolerant breeding line in ‘Bob’ background
- Greenhouse and Field Resistance in spray trials
- WSU multi-location Variety Testing trials in 2013
- Genetic mapping of AHAS mutation

2012 Spray Trials

- Four genotypes: Bob, Champion, Jedd, 07M-0-R1
- Split-block RCBD with 4 reps and two locations in Pullman, WA
- Beyond® herbicide (part of Clearfield Production System – BASF) was applied at 5oz/acre 29 days after planting during the 4 leaf stage

Herbicide Tolerance Spray Trials

Variety	Spray Treatment	Survival %	Yield Lb/a	TW Lb/Bu	Protein %
Bob	No-Spray	100	4972	53.5	9.6
Champion	No-Spray	100	5111	53.3	10.7
Jedd (wheat)	No-Spray	100	3972	59.8	11.9
07M-0-R1	No-Spray	100	4866	**54.5**	**11.9**

Herbicide Tolerance Spray Trials

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	Spray	0	0	0	0
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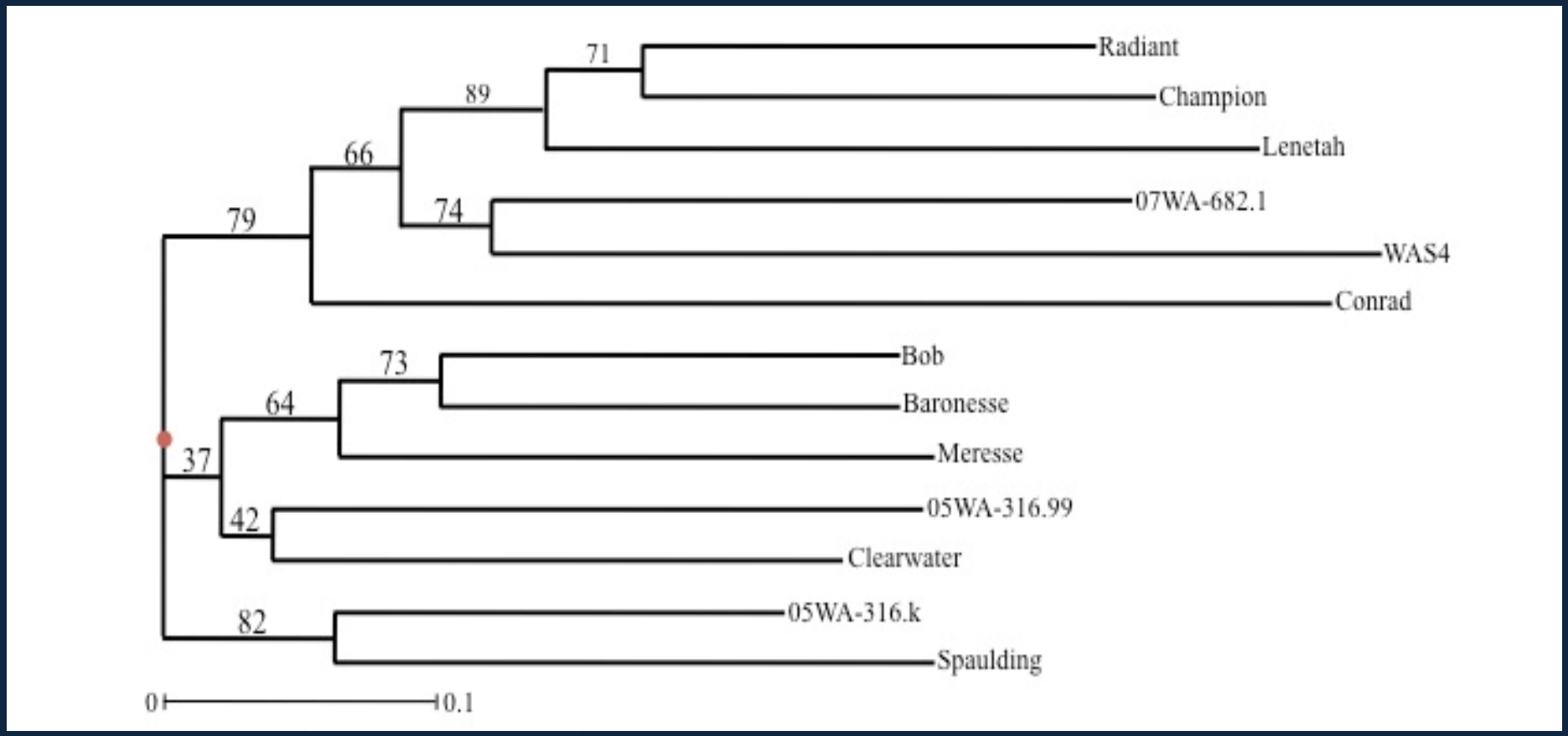
Champion	No-Spray	100	5111	53.3	10.7
	Spray	0	0	0	0
Jedd (wheat)	No-Spray	100	3972	59.8	11.9
	Spray	100	3802	59.9	11.7
07M-0-R1	No-Spray	100	4866	54.5	11.9
	Spray	**100**	**4812**	**53.4**	**12.7**

Mapping

Genetic mapping of acetohydroxyacid synthase (AHAS*)* gene, mutation provides IMI resistance

- Used 62 barley SSR markers specific to chromosome 6H to assess the genetic diversity among 13 barley genotypes
- Determined that WAS4 is most divergent from 'Bob'
- Mutant Bob x WAS4 F_2 (2000 seeds) will be used for mapping the AHAS gene in chromosome 6H

Genetic diversity among barley genotypes

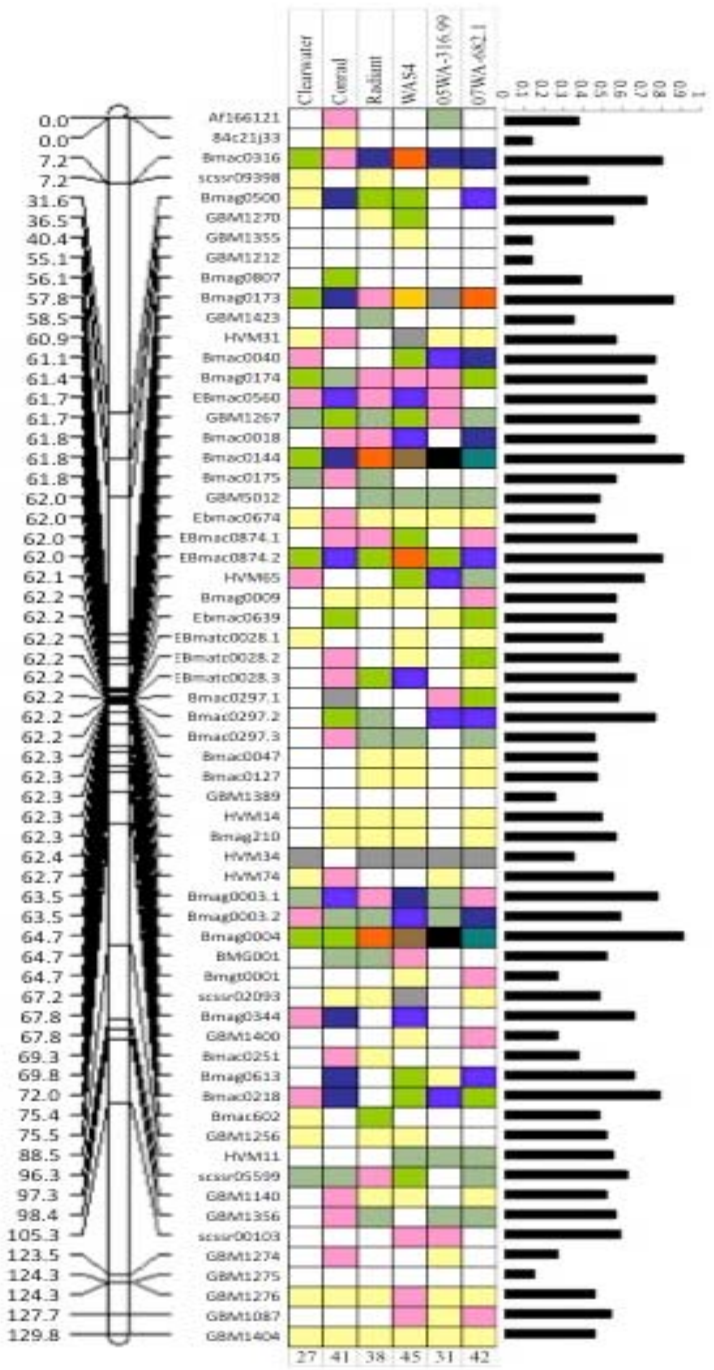


3 main clusters from the genetic distance matrix, used the Darwin 5.0 software to compute an un-weighted Neighbor-Joining tree

Genetic dissimilarity

Genotype	Baronesse	Bob	Champion	Clearwater	Lenetah	Conrad	Radiant	Spaulding	WAS4	05WA-316.99	05WA-316.k	07WA-682.1
Bob	0.339											
Champion	0.565	0.661										
Clearwater	0.500	0.435	0.565									
Lenetah	0.677	0.677	0.516	0.629								
Conrad	0.645	0.661	0.677	0.710	0.710							
Radiant	0.516	0.613	0.355	0.565	0.435	0.645						
Spaulding	0.677	0.581	0.613	0.548	0.645	0.742	0.742					
WAS4	0.774	0.726	0.629	0.710	0.677	0.806	0.613	0.677				
05WA-316.99	0.516	0.500	0.710	0.452	0.726	0.742	0.629	0.500	0.742			
05WA-316.k	0.516	0.484	0.597	0.468	0.694	0.629	0.613	0.387	0.694	0.468		
07WA-682.1	0.645	0.677	0.565	0.645	0.565	0.694	0.548	0.581	0.565	0.613	0.548	
Meresse	0.419	0.435	0.694	0.548	0.694	0.758	0.629	0.516	0.677	0.500	0.516	0.629

The genetic dissimilarity coefficient values were calculated for all possible 78 pairs of genotypes; high level of genetic diversity, with the highest between ‘Bob’ and WAS4



Genetic linkage map of chromosome 6H showing the respective location of the 62 markers used in the study.

Various alleles detected from the six barley genotypes used for crossing with Bob *AHAS* mutants are indicated by colored boxes, where each color represents a unique allele and white represents a Bob-type allele.

The total number of polymorphic markers identified per genotype pair with the Bob mutant is shown below.

The polymorphic information content (PIC) values calculated for each marker was plotted against its location on the genetic linkage map to indicate the level of nucleotide diversity among the 13 barley genotypes.

Transfer of IMI resistance gene

Class	Female	# of Crosses	F1 seeds
Feed	05WA-316.99	53	482
Feed	07WA-682.1	29	403
Malting	Radiant	37	380
Malting	Conrad	35	454
Food	Clearwater	38	403
Food	WAS4	38	431

Transfer of IMI-resistance from 'Bob' to selected genotypes – In each cross, the Bob mutant served as male parent, 2000 F_2 plants will be screened for the presence of the *AHAS* mutant allele with SSR markers

Herbicide Resistant Barley Next Steps

- Include in Variety Testing in 2013
- Include in a no-spray nursery following herbicide application
- Winter Survival / Capacity to become a weed in Winter Wheat
- Incorporation into higher yielding malting, feed & food backgrounds
- Technology ownership / licensing

Acknowledgements

- American Malting Barley Association (AMBA)
- Washington Grain Commission
- Washington Wheat Foundation
- T-CAP
- Clif Bar Family Foundation
- Charlie Mops