From Our Fields to Your Table?

A Look at the Virginia Tech Bread Wheat Project and Possible Implications for the Future of Wheat Production in Virginia

Seminar by Wendy Rohrer, Research Associate, CSES

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From Our Fields to Your Table?

A Look at the Virginia Tech Bread Wheat Project and Possible Implications for the Future of Wheat Production in Virginia

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Topics to be discussed:

- What is “bread wheat”?
- The nutritional value of wheat products
- Production of wheat in Virginia
- The Virginia Tech Small Grains Bread Wheat Project

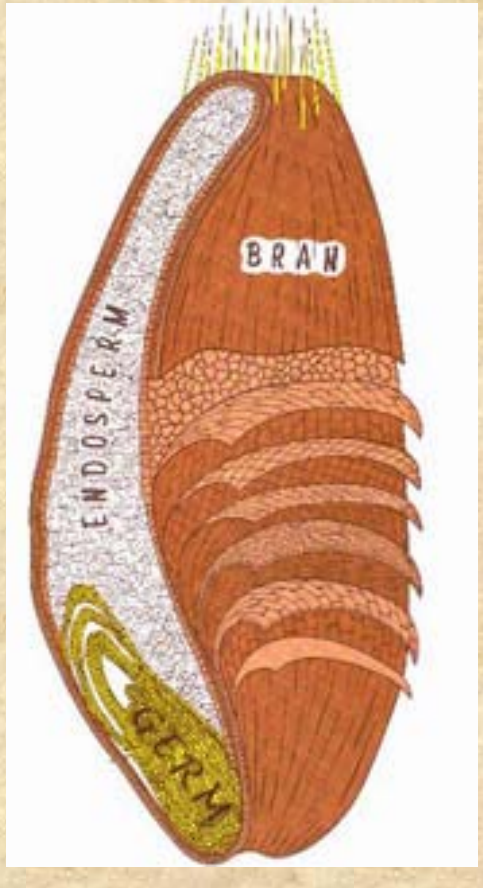
Part I

Introduction to Bread Wheat

What is "bread wheat?"

- *Triticum aestivum* L. (hexaploid, various growth forms and habits)
- Is of a particular class or classes of wheat
- Typically has moderate to high protein content and good to superior milling and baking qualities
  - May contain specific allelic forms of particular gluten proteins

A Wheat Kernel Up Close



- Endosperm
  - ~83% of kernel
- Bran
  - ~14.5% of kernel
- Germ
  - ~2.5% of kernel

Summary of the Six Basic Classes of Wheat[1]

Class	Characteristics	Uses	Primary Production Areas
Hard Red Winter	Wide range of protein content, good milling and baking qualities	Bread, rolls, some sweet goods and all-purpose flour	Great Plains states, Mississippi River west to the Rocky Mountains and from Canada to Mexico
Hard Red Spring	Highest percentage of protein, superior milling and baking qualities	Excellent bread wheat	Montana, North Dakota, South Dakota, and Minnesota
Soft Red Winter	High yielding, relatively low protein	Flat breads, cakes, pastries, and crackers	Primarily east of the Mississippi
Hard White Winter	Milder, sweeter flavor than red wheats; equal fiber and similar milling and baking qualities as red wheats; differs in "color" genes	Yeast breads, hard rolls, bulgur, tortillas, and Oriental noodles	Newest class to be grown in the U.S.
Soft White Winter	Same as hard white winter, low protein, high yielding	Cakes, crackers, cookies, pastries, quick breads, muffins, and snack foods	Pacific Northwest and some in California, Michigan, Wisconsin and New York
Durum	Hardest of all U.S. wheats	Semolina flour for pasta production	Same northern states as Hard Red Spring; 70-80% of the U.S. annual production comes from North Dakota

[1] After http://www.smallgrains.org/WHFACTS/6classwh.htm

Wheat Flours

- White Flour
- Whole Wheat Flour
- Self-Rising Flour
- *Cake Flour (7-9% protein)*
- *Pastry Flour (8-9% protein)*
- *All-Purpose Flour (8-11% protein)*
- *Bread Flour (12-14% protein)*
- *Gluten Flour (40-45% protein)*

Wheat is the only grain with sufficient gluten* content to make raised or leavened bread.

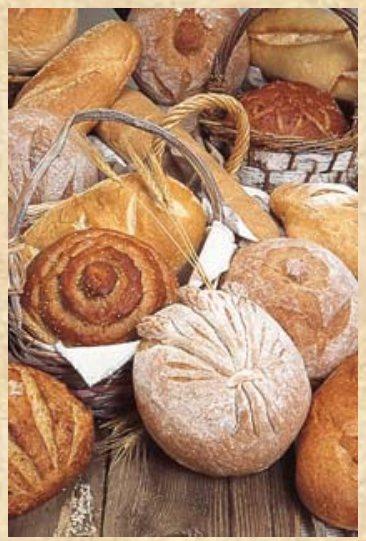
* Gluten gives bread dough elasticity, strength, and gas-retaining properties.

Hard Red Winter Wheat

Hard Red Spring Wheat

Soft Red Winter Wheat

Hard White Winter Wheat



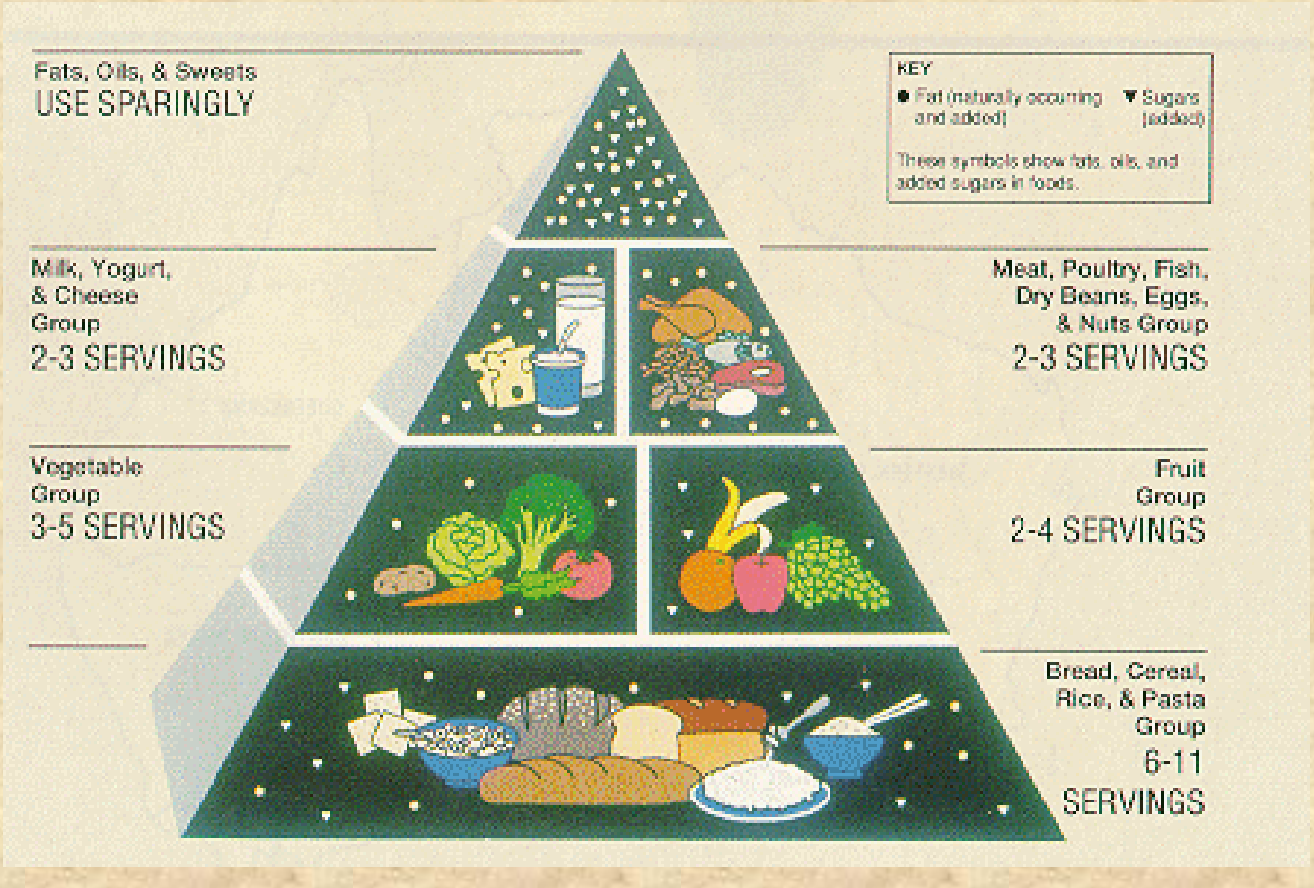
Soft White Winter Wheat

Durum Wheat

Part II

Wheat Products for Healthful Living

USDA's Food Guide Pyramid



The *Grain Group* of the Food Guide Pyramid

- Includes bread, cereal, pasta, and rice
- 6-11 servings daily
  - Consider age and activity level
- Is it difficult to get 6-11 servings?

One serving from the grain group equals:

- One slice of bread
- 1/2 bagel, hamburger or hot dog bun, dinner roll or English muffin
- 1 oz. Ready-to-eat cereal (3/4 cup)
- 1/2 cup cooked cereal, pasta, bulgur, couscous, rice or barley
- 1 small tortilla
- 4 saltine crackers
- 1 pancake or waffle
- 1/2 pita bread
- 3 fig bar cookies

Why so many servings from the grain group?

- Source of complex carbohydrates
- Grain products have less than half the calories, gram for gram, of fat
- Source of vitamins, minerals, and fiber

Nutritional composition of bread (per 100g).			
	White	Brown	Wholemeal
Carbohydrate	49.3	44.3	41.6
Protein	8.4	8.5	9.2
Dietary Fiber	2.7	4.7	7.1
Fat	1.9	2.0	2.5
(Cauvain and Young, 1998)			

Part III

Wheat Production in Virginia

How does Virginia compare to other wheat producing states?

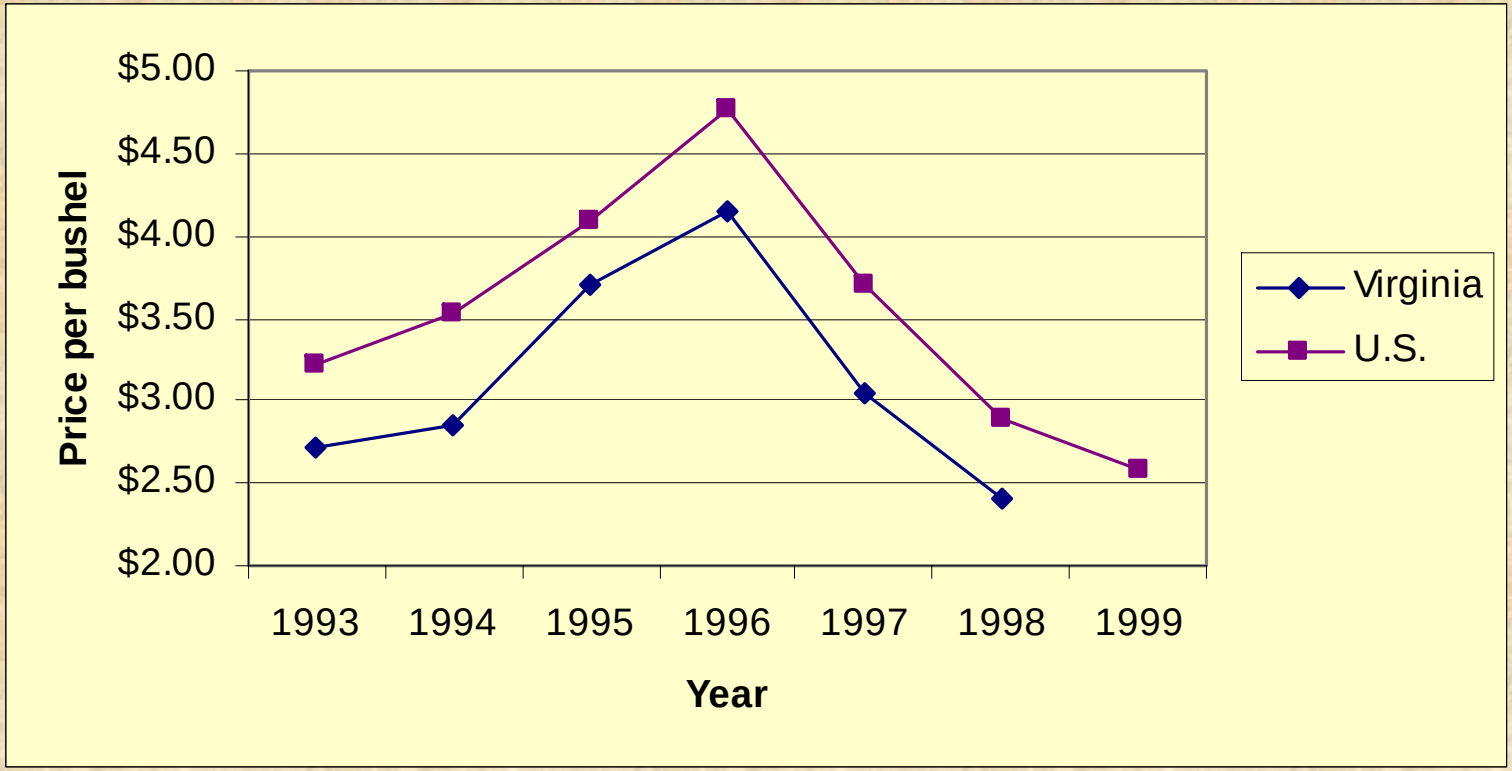
- 1997: VA ranked 22nd out of the top 40 wheat producing states in the U.S. with 17.4 million bushels.
- 1998: VA ranked 24th with 11.0 million bushels.
- 1999: VA ranked 23rd with 13.6 million bushels.
- Kansas consistently ranked 1st with 501.4, 494.9, and 432.4 million bushels produced in 1997, 1998, and 1999, respectively.

Total Wheat Production in the U.S. by Class (million bushels), 1996 and 1997.

1995-96	HRW	HRS	SRW	White	Durum	Total
Production	824	475	450	334	102	2186
% of Total U.S. Production	37.7	21.7	20.6	15.3	4.7	100
Exports	383	330	255	245	37	1250
% of Total U.S. Export	30.6	26.4	20.4	19.6	3.0	100
1996-97						
Production	847	476	444	314	105	2187
% of Total U.S. Production	38.7	21.8	20.3	14.4	4.8	100
Exports	375	310	225	220	45	1175
% of Total U.S. Export	31.9	26.4	19.1	18.7	3.8	100

Minnesota Association of Wheat Growers' web site: http://www.smallgrains.org/WHFACTS.HTM

Price Per Bushel of Wheat in Virginia[1] and the U.S.[2], 1993-99



[1] Virginia Agricultural Statistics 1998 Annual Bulletin. 1999. Virginia Agricultural Statistics Service, Richmond, VA.

[2] Minnesota Association of Wheat Growers' web site: http://www.smallgrains.org/WHFACTS.HTM

Is there a market for hard wheat in VA?

- Mills
  - In Virginia
    - Cargill
    - Mennel Milling Company
  - In near-by Maryland
    - ConAgra
- Exporting
  - Advantage of having coastal state border

Part IV

The VA Tech Bread Wheat Project

Why is the Virginia Tech Small Grains Program interested in bread wheat?

- Many attributes that determine bread-making quality are genetically determined, thus, may be selected for by the breeder.
- Potential for use as cultivated crop in Virginia: Open new market for Virginia farmers
- Make use of local (in-state and neighboring) milling operations
- Allows for cooperation between CSES and HNFE

Current Projects

- Annual Bread Wheat Yield Test
- Quality Testing
  - Milling quality
  - Baking quality
- SDS-PAGE Analysis
  - HMW subunits (Glutenins)

Annual Bread Wheat Yield Test

- 2 years (harvested in 1999 and 2000)
- 30 entries
- 3 replications
- 3 locations
  - Blacksburg, VA
  - Warsaw, VA
  - Painter, VA
- Assessment of field characters as well as yield and test weight

Summary of Entries

- Included are:
  - 1 released hard white winter wheat (Heine)
  - 5 European wheat varieties (Balkan, 4 French lines)
  - 21 experimental hard red winter wheats
  - 3 soft red winter wheats (Pioneer 2643, 2137, North Carolina experimental line)

Summary of Results for Selected Entries in the 1999 and 2000 Bread Wheat Yield Tests

Entry	Wheat Class	2000 Yield (bu/a)	Rank (2000)	1999 Yield (bu/a)	Rank (1999)	1999/00 Avg. Yield (bu/a)	Rank (99/00)*
30	SRW	78.6	1	83.9	1	81.3	1
17	HRW	75.4	2	76.0	4	75.7	2
1	SRW	72.6	4	78.2	2	75.4	3
5	EUR/FR	73.7	3	75.9	5	74.8	4
21	HRW	72.1	5	75.6	6	73.9	5
4	EUR/FR	70.0	7	76.9	3	73.5	6
22	HRW	71.3	6	67.2	12	69.3	7
11	HRW	69.4	9	68.7	9	69.1	8
28	HRW	67.4	12	69.6	7	68.5	9
2	EUR/FR	68.8	10	67.6	11	68.2	10
10	HRW	65.6	17	69.3	8	67.5	11
29	HRW	69.6	8	64.5	18	67.0	13
24	HRW	65.9	16	67.9	10	66.9	14
Test Mean		66.7		67.2		66.9	

* Entry 6 ranked 12th overall (11th in 2000 and 14th in 1999) with a yield of 67.1 bu/a.

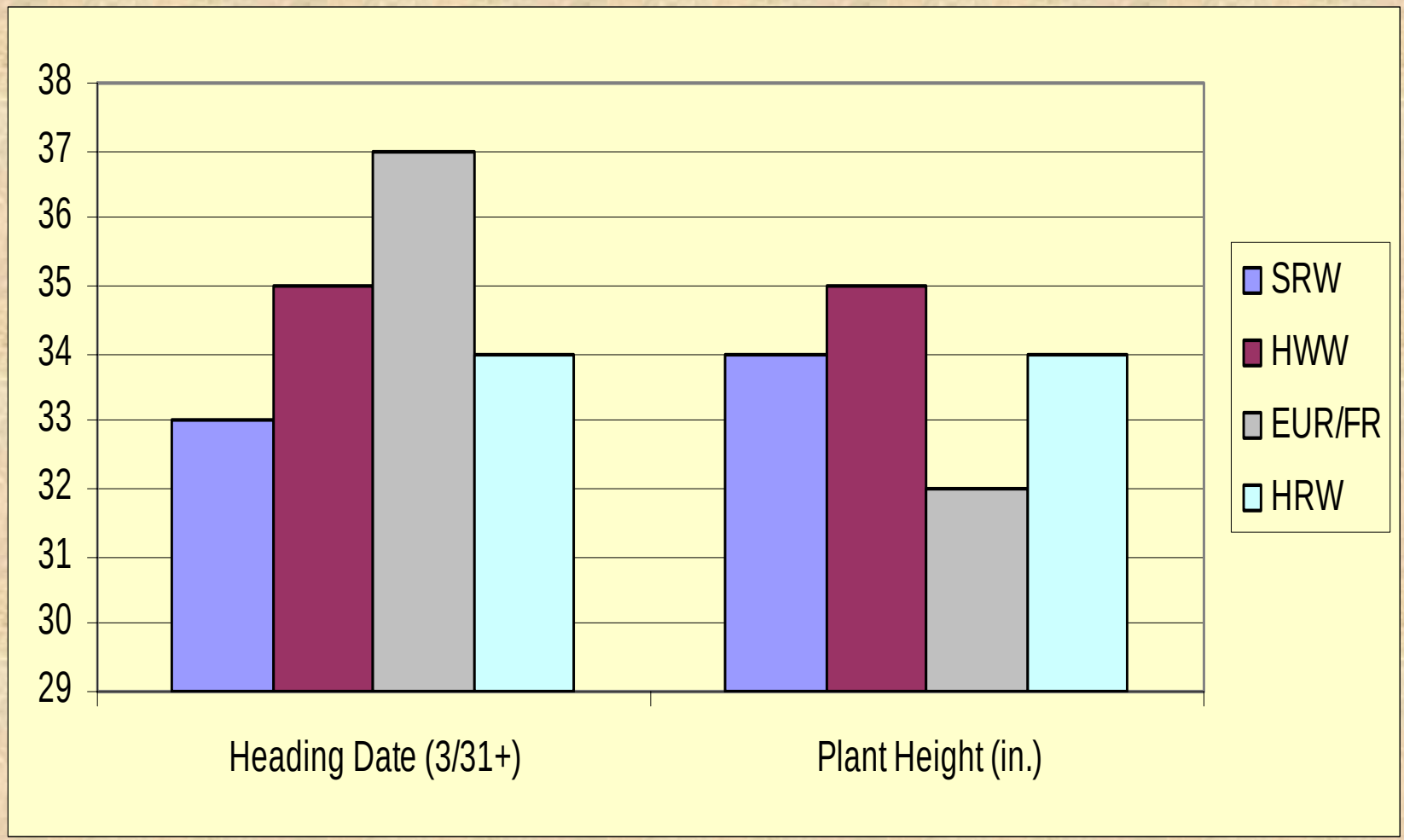
Summary of Results for Selected Entries in the 1999 and 2000 Bread Wheat Yield Tests

Entry	2000 Test Weight (lbs/bu)	1999 Test Weight (lbs/bu)	1999/00 Avg. Test Weight (lbs/bu)
SRW	57.6	58.8	58.2
HRW	56.5	58.7	57.6
SRW	59.3	60.4	59.9
EUR/FR	56.0	57.8	56.9
HRW	57.4	57.9	57.7
EUR/FR	56.2	57.7	57.0
HRW	57.7	59.0	58.4
HRW	56.8	57.6	57.2
HRW	58.0	59.7	58.9
EUR/FR	56.6	58.4	57.5
HRW	57.4	58.1	57.8
HRW	57.8	59.2	58.5
HRW	58.0	59.4	58.7
Test Mean	57.2	58.4	57.8

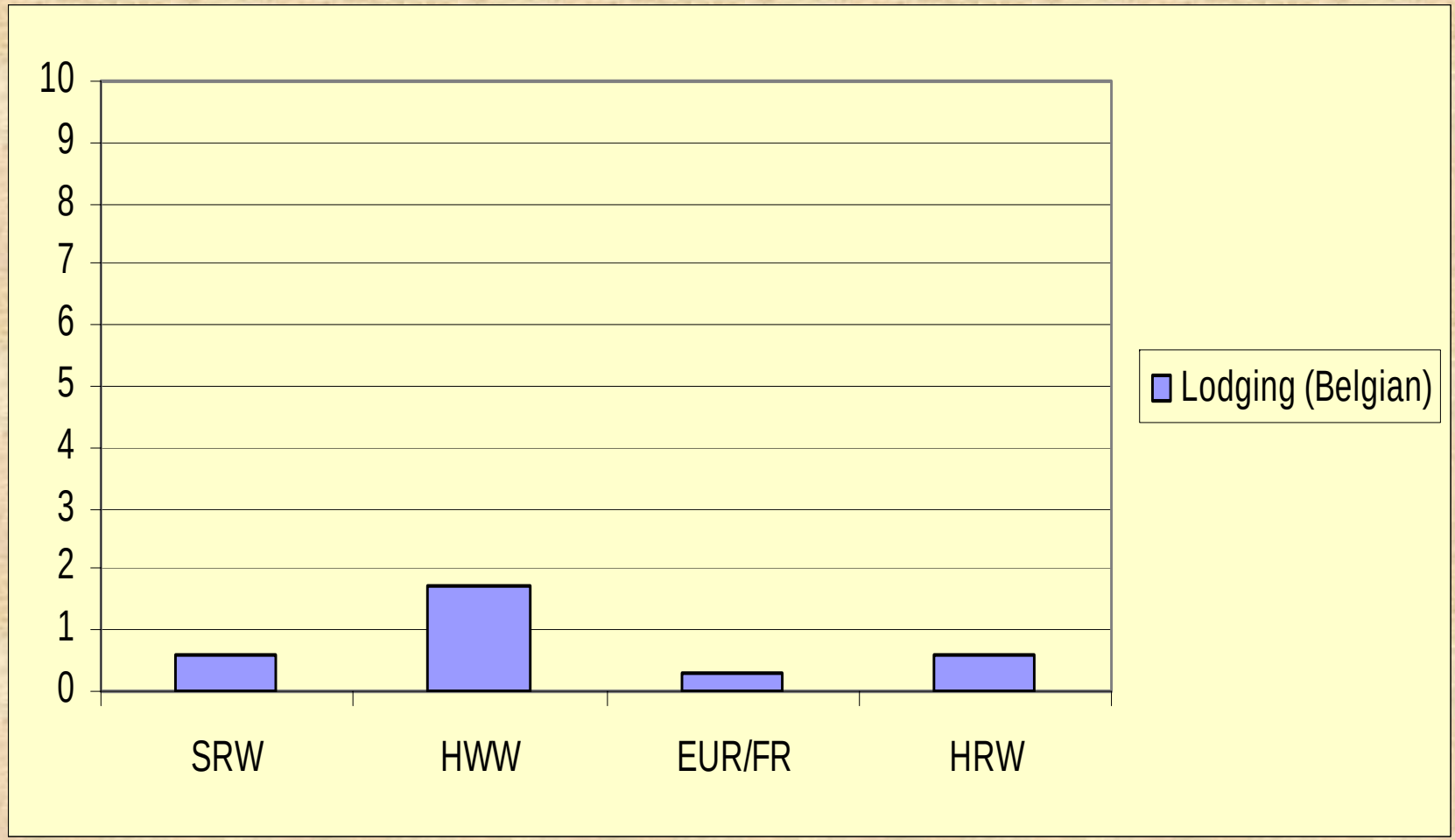
Field Traits by Grain Type

- Field traits examined include but are not limited to:
  - Heading date
  - Plant height
  - Lodging
  - Relative disease severity

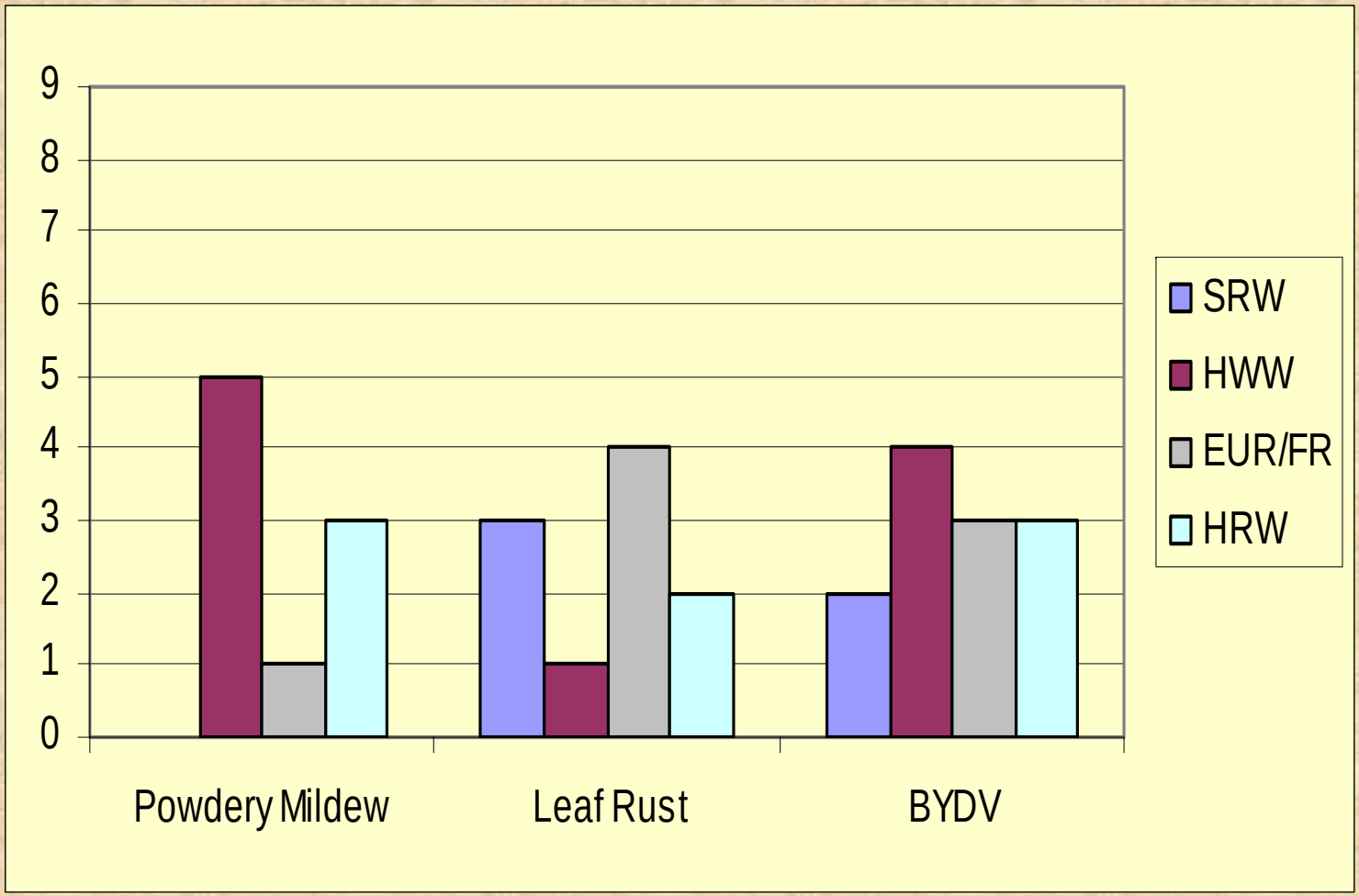
Summary of Two Field Traits by Wheat Class, 1999 and 2000



Summary of Lodging Data by Wheat Class, 1999 and 2000



Summary of Disease Data by Wheat Class, 1999 and 2000



Summary of Performance of Entries in the Virginia Tech Bread Wheat and State Wheat Tests Over Two Years at Three Locations

	Bread Wheat Test 1999 and 2000	State Wheat Test 1999 and 2000
Yield	66.9	85.9
Test Weight	57.8	58.3
Heading Date	34	33
Plant Height	34	36
Lodging	0.7	0.7
Powdery Mildew	3	1
Leaf Rust	2	3
BYDV	2	2

Quality Testing

- Performed by P. Finney (USDA)
- Milling quality
  - Flour yield
- Baking quality
  - % protein
  - Softness equivalent
  - Cookie diameter
  - Lactic acid content
  - Loaf volume
  - Gluten strength

Summary of Results for Selected Entries in the 1999 Bread Wheat Quality Study

SRW	Quality Rank	Adjusted Flour Yield	Softness Equivalent	Protein (%)	Cookie Diameter	Lactic Acid Content	Loaf Volume	Gluten Strength (based on farinograph MTS and MTI values)
SRW	11	73.7	56.1	7.7	18.3	121.3	595	weak
HRW	16	77.0	41.7	8.7	15.4	121.0	645	moderate
SRW	5	74.3	51.9	8.1	18.9	96.9	680	moderate
EUR/FR	12	77.4	47.6	8.1	16.1	108.4	625	strong
HRW	1	74.1	60.0	7.5	18.1	109.5	695	weak
EUR/FR	8	77.7	47.4	7.9	16.6	105.8	625	weak
HRW	2	72.5	59.5	7.8	18.2	112.7	710	weak
HRW	9	74.8	46.9	8.8	16.2	111.7	685	strong
HRW	4	73.1	56.5	8.4	17.9	113.3	700	weak
EUR/FR	30	75.4	36.0	9.1	15.4	111.7	560	weak
HRW	24	76.1	42.6	9.3	15.5	109.5	610	weak
HRW	14	73.4	55.4	8.6	17.7	108.7	650	moderate
HRW	21	76.3	41.5	9.0	15.5	119.1	630	moderate

SDS-PAGE Analysis

- Cooperative project with HNFE
- Assayed 30 original entries using SDS-PAGE in triplicate
- Looking for HMW subunits (glutenin); in particular, combos of 5 + 10 and 2 + 12
  - 5 + 10 desirable
  - 2 + 12 undesirable

Proteins in Bread Wheat

- Proteins in the seed/flour determine suitability for use as bread wheat
  - Gluten proteins
    - Gliadin
      - very sticky, almost liquid when hydrated
      - provide cohesiveness and extensibility
    - Glutenin
      - resilient and rubbery but prone to rupture
      - provide dough strength/resistance to extension
    - Combined, the gluten proteins give dough its viscoelastic properties

Summary of Results for Selected Entries in the 1999 Bread Wheat SDS-PAGE/Quality Analyses

Grain Type	Presence of HMW Subunits 5+10	Gluten Strength	Loaf Volume
SRW	positive	weak	595
HRW	negative	moderate	645
SRW	positive	moderate	680
EUR/FR	positive	strong	625
HRW	negative	weak	695
EUR/FR	positive	weak	625
HRW	positive	weak	710
HRW	negative	strong	685
HRW	positive	weak	700
EUR/FR	positive	weak	560
HRW	positive	weak	610
HRW	positive	moderate	650
HRW	positive	moderate	630

Part V

Food for Thought

Consider this...

- ...U.S. hard wheat varieties are very desirable due to their excellent milling and baking qualities.
- ...Virginia's climate is suitable for successfully growing "appropriate" varieties of hard wheat.
- ...Hard wheat varieties can provide Virginia farmers with another option.
- ...Production of hard wheat in the Commonwealth could perhaps reduce the cost paid by consumers for baked goods.
- ...Tobacco.
- ...Consumption of soft wheat products may be declining. . .

Per Capita Consumption of Bread and Related Products in Lbs. (Faridi and Faubion, 1995)

	1988	1989	1990	1991*	1992*	1993#	1994	1995	1996	1997	1998	1999	2000	2001
All Bread	48.7	49.3	49.9	50.5	51.2	52.0	52.9	53.8	54.8	55.9	57.0	58.2	59.5	60.6
Rolls	21.7	22.3	22.8	23.1	23.5	23.9	24.3	24.7	25.1	25.4	25.6	25.9	26.2	26.7
Sweet Yeast Goods	3.8	3.9	4.0	4.0	4.1	4.1	4.3	4.4	4.5	4.6	4.7	4.7	4.8	4.9
Soft Cakes	7.5	7.5	7.7	7.9	8.1	8.3	8.6	8.7	8.9	9.0	9.2	9.3	9.5	9.7
Pies*	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Cake Type Donuts*	1.2	1.3	1.2	1.1	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Cookies	12.2	12.9	12.6	12.2	12.2	12.3	12.6	12.9	13.2	13.4	13.5	13.7	13.9	14.0
Crackers*	8.0	8.0	8.1	8.1	8.2	8.2	8.4	8.6	8.9	9.0	8.3	7.6	6.9	6.1
Pretzels*	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.3	1.1	1.0	0.8

Final Remarks

The ultimate goal of our research project is to identify hard wheat varieties that are able to produce high quality breads and that are either potential sources of germplasm or are suited for Virginia's environment.

The purpose for introducing hard wheat varieties to the eastern U.S. is not to displace soft wheat varieties but instead to supplement them and provide producers with another option.

Thank you!