Update on NFPT and SCRI: We're off to the races

Update at NCP Summer Meeting for
SCRI NFPT Subcommittee

Walla Walla WA, June 25, 2013

Update on acrylamide and human health

- Neurotoxicity
- Carcinogenesis
- Reproductive and developmental defects

Expanded proposition 65 warning

OEHHA
Office of Environmental Health Hazard Assessment

Acrylamide
[2011]

Acrylamide is on the Proposition 65 list of chemicals known to the state to cause cancer or reproductive toxicity (such as birth defects and other reproductive harm).

Research on prenatal development and acrylamide

Birth Weight, Head Circumference, and Prenatal Exposure to Acrylamide from Maternal Diet: The European Prospective Mother–Child Study (NewGeneris)

Environmental Health Perspectives
2012 vol. 120 (12) pp. 1739-1745

Conclusions of the authors:

- Dietary exposure to acrylamide was associated with reduced birth weight and head circumference.
- Consumption of specific foods during pregnancy was associated with higher acrylamide exposure *in utero.*
- If confirmed, these findings suggest that dietary intake of acrylamide should be reduced among pregnant women.

Potato breeding in the 21st century

- Molecular markers linked to high value traits
- Association mapping using less structured populations
- Specific mapping populations
- Accurate characterization of traits is the biggest challenge

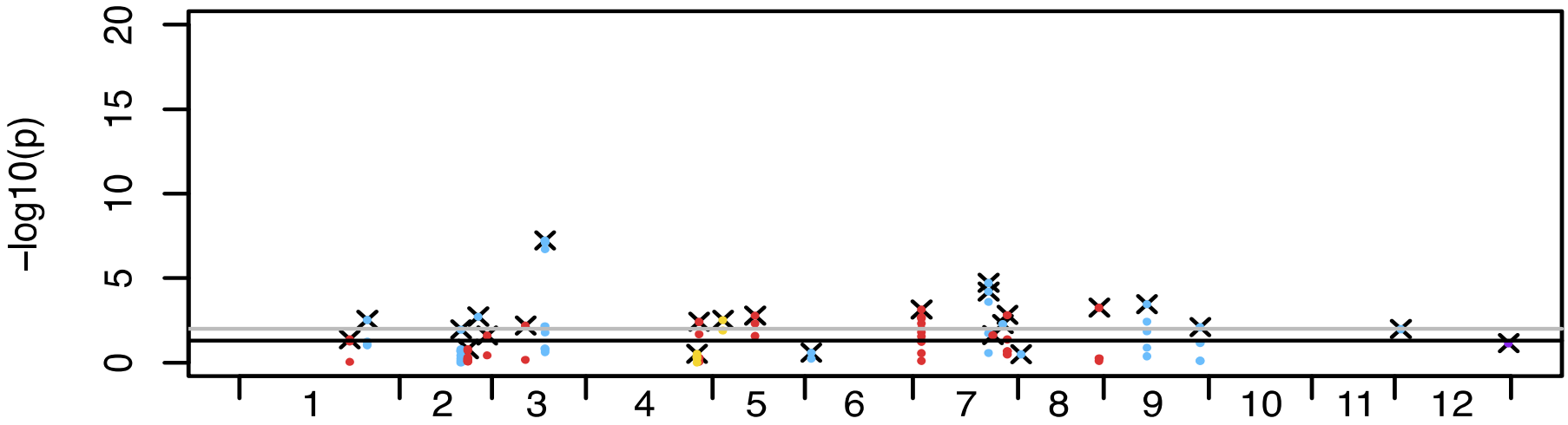
Potato breeders have selected for carbohydrate synthesis, degradation, transport, and regulatory genes

Retrospective View of North American Potato (*Solanum tuberosum* L.) Breeding in the 20th and 21st Centuries

Candice N. Hirsch,* Cory D. Hirsch,* Kimberly Felcher,† Joseph Coombs,† Dan Zarka,† Allen Van Deynze,‡ Walter De Jong,§ Richard E. Veilleux,** Shelley Jansky,††,‡‡ Paul Bethke,††,‡‡ David S. Douches,†
and C. Robin Buell*,1

G3, 2013

Strong enrichment for carbohydrate-related genes

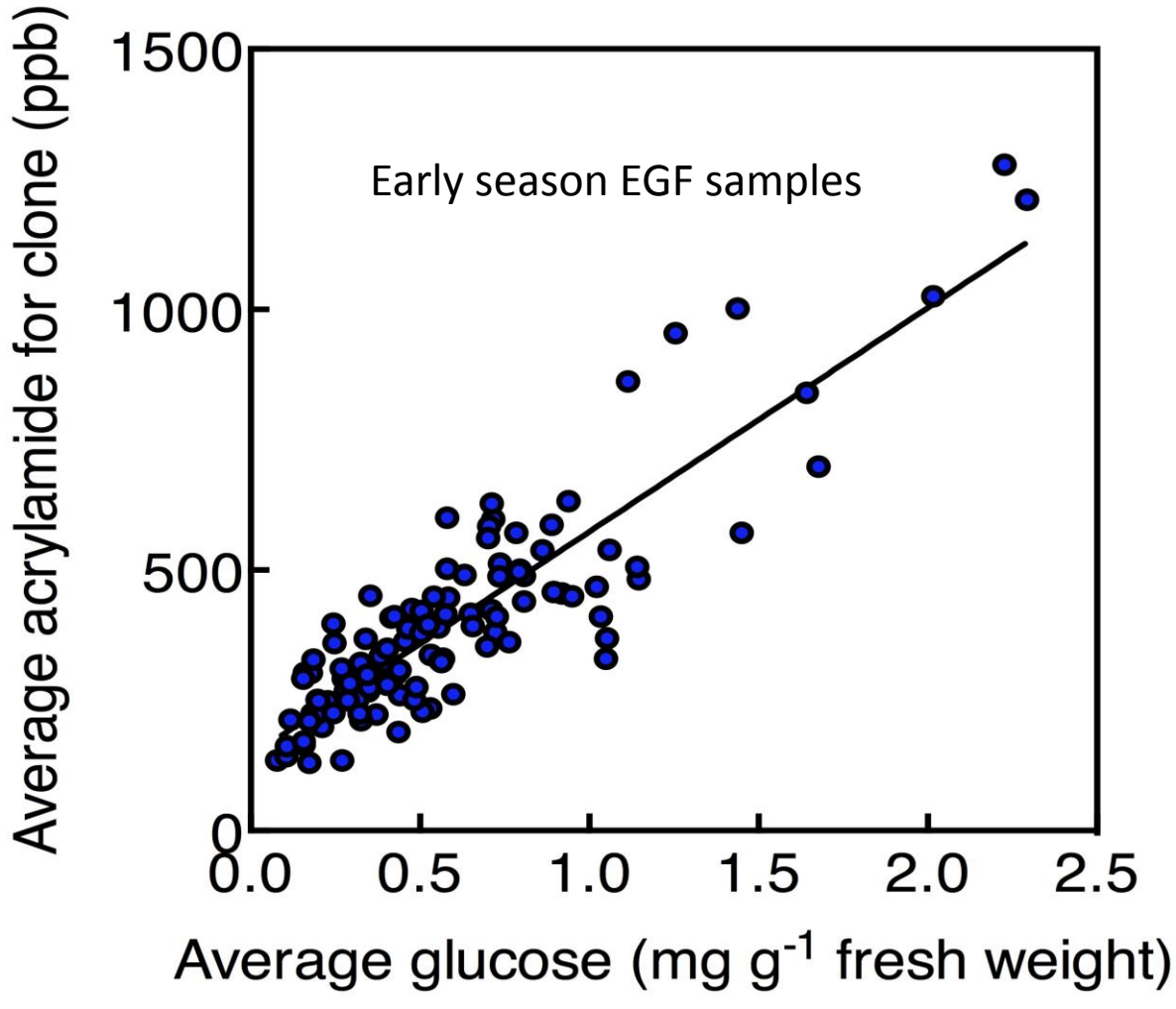


Hirsch et al, 2013

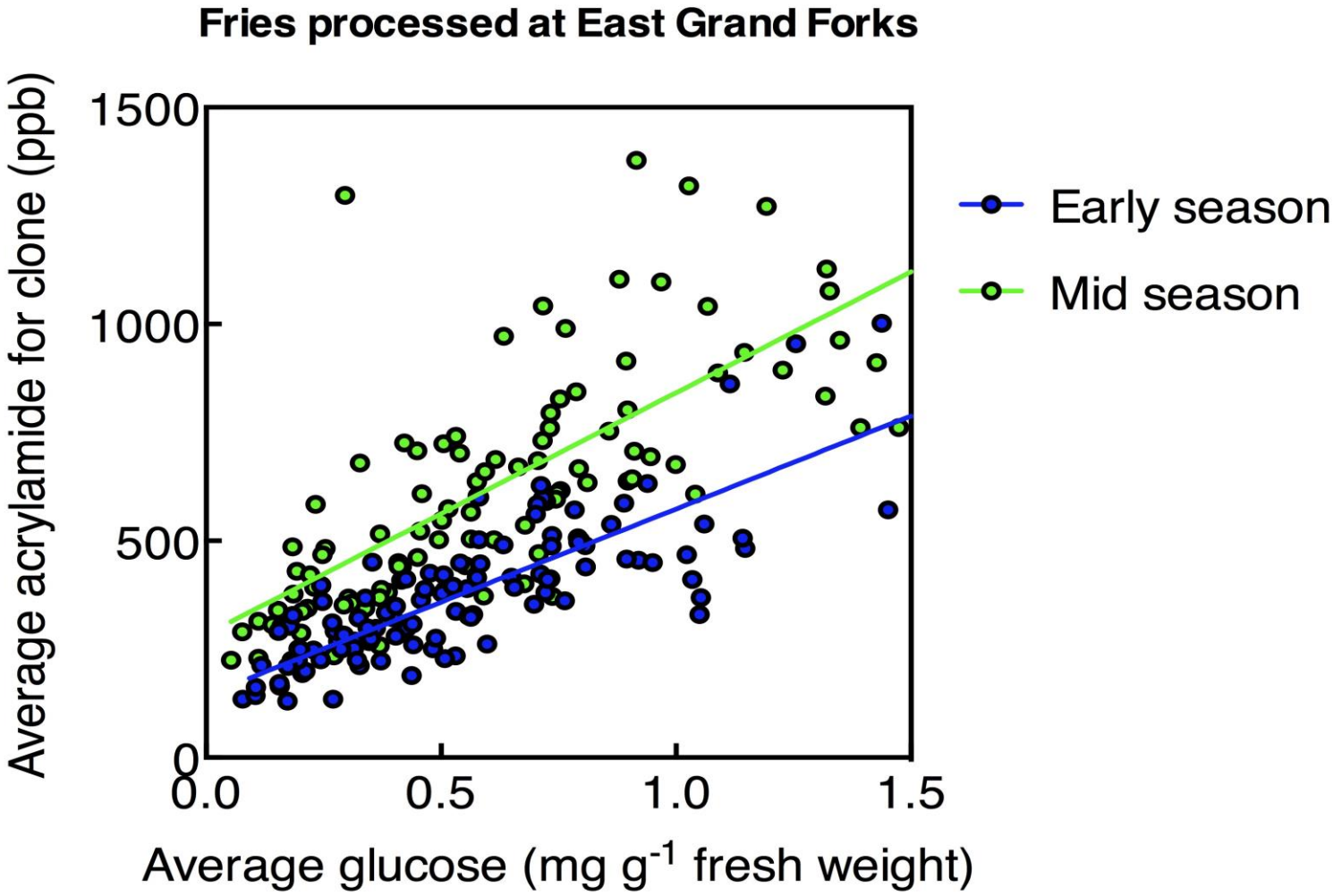
Developing molecular markers for low-acrylamide fry processing clones

- Premier Russet x Rio Grand Russet mapping population developed in SolCAP project
- Selected 45 clones for asparagine and acrylamide analysis
- Replicate plots in Idaho and Michigan
- Use data to identify genetic loci linked to acrylamide content

Reducing sugars are a strong determinant of fry acrylamide

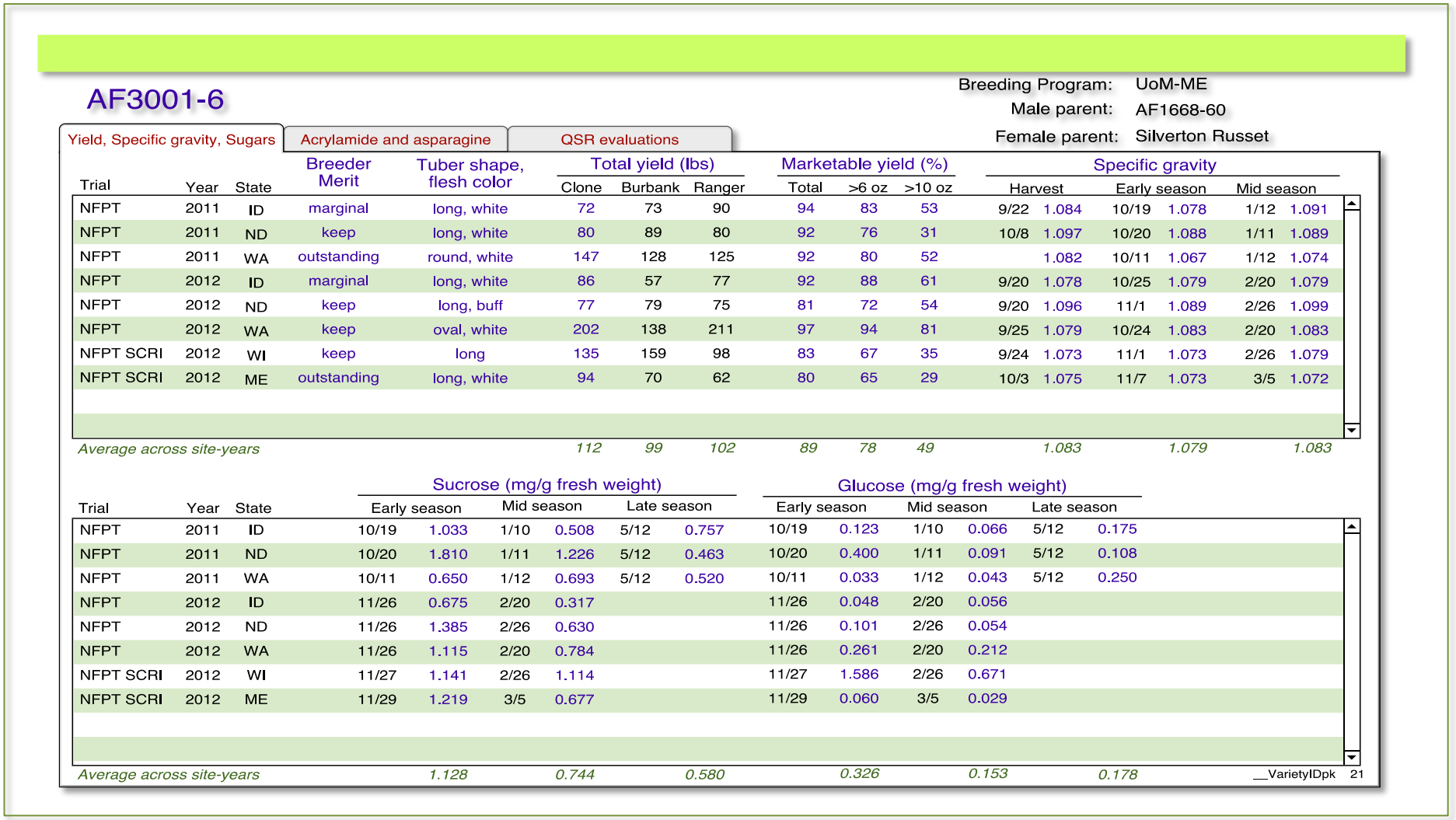


Reducing sugars don’t explain all variation in acrylamide



NFPT database is on the web

http://hort-fms.cals.wisc.edu/fmi/iwp/res/iwp_home.html



AF3001-6

Breeding Program: UoM-ME
Male parent: AF1668-60
Female parent: Silverton Russet

Yield, Specific gravity, Sugars | Acrylamide and asparagine | QSR evaluations

Trial	Year	State	Breeder Merit	Tuber shape, flesh color	Total yield (lbs)			Marketable yield (%)			Specific gravity					
					Clone	Burbank	Ranger	Total	>6 oz	>10 oz	Harvest		Early season		Mid season	
NFPT	2011	ID	marginal	long, white	72	73	90	94	83	53	9/22	1.084	10/19	1.078	1/12	1.091
NFPT	2011	ND	keep	long, white	80	89	80	92	76	31	10/8	1.097	10/20	1.088	1/11	1.089
NFPT	2011	WA	outstanding	round, white	147	128	125	92	80	52		1.082	10/11	1.067	1/12	1.074
NFPT	2012	ID	marginal	long, white	86	57	77	92	88	61	9/20	1.078	10/25	1.079	2/20	1.079
NFPT	2012	ND	keep	long, buff	77	79	75	81	72	54	9/20	1.096	11/1	1.089	2/26	1.099
NFPT	2012	WA	keep	oval, white	202	138	211	97	94	81	9/25	1.079	10/24	1.083	2/20	1.083
NFPT SCRI	2012	WI	keep	long	135	159	98	83	67	35	9/24	1.073	11/1	1.073	2/26	1.079
NFPT SCRI	2012	ME	outstanding	long, white	94	70	62	80	65	29	10/3	1.075	11/7	1.073	3/5	1.072
Average across site-years					*112*	*99*	*102*	*89*	*78*	*49*		*1.083*		*1.079*		*1.083*

Trial	Year	State	Sucrose (mg/g fresh weight)						Glucose (mg/g fresh weight)					
			Early season		Mid season		Late season		Early season		Mid season		Late season	
NFPT	2011	ID	10/19	1.033	1/10	0.508	5/12	0.757	10/19	0.123	1/10	0.066	5/12	0.175
NFPT	2011	ND	10/20	1.810	1/11	1.226	5/12	0.463	10/20	0.400	1/11	0.091	5/12	0.108
NFPT	2011	WA	10/11	0.650	1/12	0.693	5/12	0.520	10/11	0.033	1/12	0.043	5/12	0.250
NFPT	2012	ID	11/26	0.675	2/20	0.317			11/26	0.048	2/20	0.056		
NFPT	2012	ND	11/26	1.385	2/26	0.630			11/26	0.101	2/26	0.054		
NFPT	2012	WA	11/26	1.115	2/20	0.784			11/26	0.261	2/20	0.212		
NFPT SCRI	2012	WI	11/27	1.141	2/26	1.114			11/27	1.586	2/26	0.671		
NFPT SCRI	2012	ME	11/29	1.219	3/5	0.677			11/29	0.060	3/5	0.029		
Average across site-years				*1.128*		*0.744*		*0.580*		*0.326*		*0.153*		*0.178*

__VarietyIDpk 21

Breeder merit and total yield

AF3001-6

Yield, Specific gravity, Sugars | Acrylamide and asparagine | QSR evaluations

Trial	Year	State	Breeder Merit	Tuber shape, flesh color	Total yield (lbs)			M
					Clone	Burbank	Ranger	T
NFPT	2011	ID	marginal	long, white	72	73	90	
NFPT	2011	ND	keep	long, white	80	89	80	
NFPT	2011	WA	outstanding	round, white	147	128	125	
NFPT	2012	ID	marginal	long, white	86	57	77	
NFPT	2012	ND	keep	long, buff	77	79	75	
NFPT	2012	WA	keep	oval, white	202	138	211	
NFPT SCRI	2012	WI	keep	long	135	159	98	
NFPT SCRI	2012	ME	outstanding	long, white	94	70	62	
Average across site-years					*112*	*99*	*102*	

Marketable yield and sp. gravity

Breeding Program: UoM-ME
Male parent: AF1668-60
Female parent: Silverton Russet

Marketable yield (%)			Specific gravity					
Total	>6 oz	>10 oz	Harvest		Early season		Mid season	
94	83	53	9/22	1.084	10/19	1.078	1/12	1.091
92	76	31	10/8	1.097	10/20	1.088	1/11	1.089
92	80	52		1.082	10/11	1.067	1/12	1.074
92	88	61	9/20	1.078	10/25	1.079	2/20	1.079
81	72	54	9/20	1.096	11/1	1.089	2/26	1.099
97	94	81	9/25	1.079	10/24	1.083	2/20	1.083
83	67	35	9/24	1.073	11/1	1.073	2/26	1.079
80	65	29	10/3	1.075	11/7	1.073	3/5	1.072
89	*78*	*49*		*1.083*		*1.079*		*1.083*

Sugar data from NFPT database

Sucrose (mg/g fresh weight)						Glucose (mg/g fresh weight)					
Early season		Mid season		Late season		Early season		Mid season		Late season	
10/19	1.033	1/10	0.508	5/12	0.757	10/19	0.123	1/10	0.066	5/12	0.175
10/20	1.810	1/11	1.226	5/12	0.463	10/20	0.400	1/11	0.091	5/12	0.108
10/11	0.650	1/12	0.693	5/12	0.520	10/11	0.033	1/12	0.043	5/12	0.250
11/26	0.675	2/20	0.317			11/26	0.048	2/20	0.056		
11/26	1.385	2/26	0.630			11/26	0.101	2/26	0.054		
11/26	1.115	2/20	0.784			11/26	0.261	2/20	0.212		
11/27	1.141	2/26	1.114			11/27	1.586	2/26	0.671		
11/29	1.219	3/5	0.677			11/29	0.060	3/5	0.029		
	1.128		*0.744*		*0.580*		*0.326*		*0.153*		*0.178*

The NFPT database contains data from QSR runs

Acrylamide (ppb)	Color Agtron	Sugar ends (# per 1.5 lb)	Color variation (# per 1.5 lb)	Acrylamide rank	Processing rank	Sensory rank
44	79	0	0	3 / 31	/ 32	26 / 32
52	77	0	0	5 / 31	/ 32	32 / 32
80	73	3	3	4 / 39	25 / 38	23 / 38
218	63	3	30	22 / 39	38 / 38	25 / 38
102	71	4	16	8 / 39	31 / 38	26 / 38

The NFPT database contains data from QSR runs

	Units				
Test date	Limp / bendovers	Hollow internal	Fluffy internal	Firm/ wet	Good exterior shell
3/29					
3/29					
10/29	28	8	48	16	68
10/29	38	14	38	10	60
10/29	24	4	52	20	66

The NFPT database contains data from QSR runs

Raw or fry attributes needing improvement
15 bend overs
23 bend overs, Increase crispness, Increase toughness, Increase mealiness, Decrease moistness, Reduce texture variation, Increase
Higher sugar ends, High texture variation, Poor shell, Moderate asparagine, Low crispness, Low persistence of crispness, Dissolves
Lots of partial color variation
Lower gravity, High sugar ends, High color variation, High texture variation, Poor shell, Low crispness, Too tender

Outcomes from Caldwell meeting

- Identified need to begin moving select lines to pivot-scale trials
- Identified need for additional data on promising clones
- Identified late season storage as a high value trait for new varieties
- Refined list of attributes
- Identified need for database of results

Progress since Caldwell

- Began moving select lines to pivot-scale trials
- SCRI trials initiated to generate additional data on promising clones
- Conducted late-season QSR tests
- Developed a database of results

Moving select lines to pivot-scale trials in SCRI

- Identified clones for NFT minituber production
- Targeting 2014 as first seed field year
- Large trials begin in 2015

Minituber production is underway for five clones

- Sklarczyk Seed Farms: AF4296-3, ND8229-3
- CSU: AC96052-1RU
- CSS: A02507-2LB, A02138-2
- Seed is available for W6234

Procedures for initiating seed production need to be streamlined

- Resources are needed for contractual seed production
- Variety protection
- Many institutions have a stake
- Delays have cost us a year for some clones

Generate expanded data set using replicated trials

SCRI Agronomic trials are in the ground

- 6 sites
- 14 clones plus Russet Burbank check
- Replicated plots
- Provide material for multiple QSR sample time periods

In-season and harvest data collection

- **In-season**
  - 50% emergence date, tuber set date, 100% canopy closure date, pre-harvest stem count
  - Vine maturity
- **Harvest**
  - Specific gravity of (6-10 oz tubers)
  - Individual tuber specific gravity
  - Tuber size/yield distribution
  - Internal defects of (10-13 oz) tubers
  - Length to width ratio of (8-10 oz) tubers
  - Fry color and sugar-end defect screening
  - Bud- and stem-end sucrose and glucose

Post-harvest storage data

- Tubers are stored @ 55˚F for three weeks and ramped to 48˚F
- Storage samples will be collected every 16 weeks: 16 wk (Feb), 32 wk (May) post harvest
- Data of fry color, sugar-end defect, bud- and stem-end sucrose and glucose will be collected

Additional QSR tests conducted this year by Simplot

- 32 clones in June 2013

Improvements in data collection for 2013

- NFPT
- SCRI
- Processor involvement

Top ten priority traits

Attribute	Total votes	QSR	Processor	Grower
% Sugar ends	14	2	4	8
Bruise free	9	0	4	5
Acrylamide	9	1	5	3
Resist Cold-sweetening	9	1	0	8
Specific gravity	8	2	5	1
Yield	8	1	4	3
Consistent solids	8	2	5	1
Size profile	7	1	4	2
% high sugar	6	2	2	2
Stores to summer	5	1	3	1

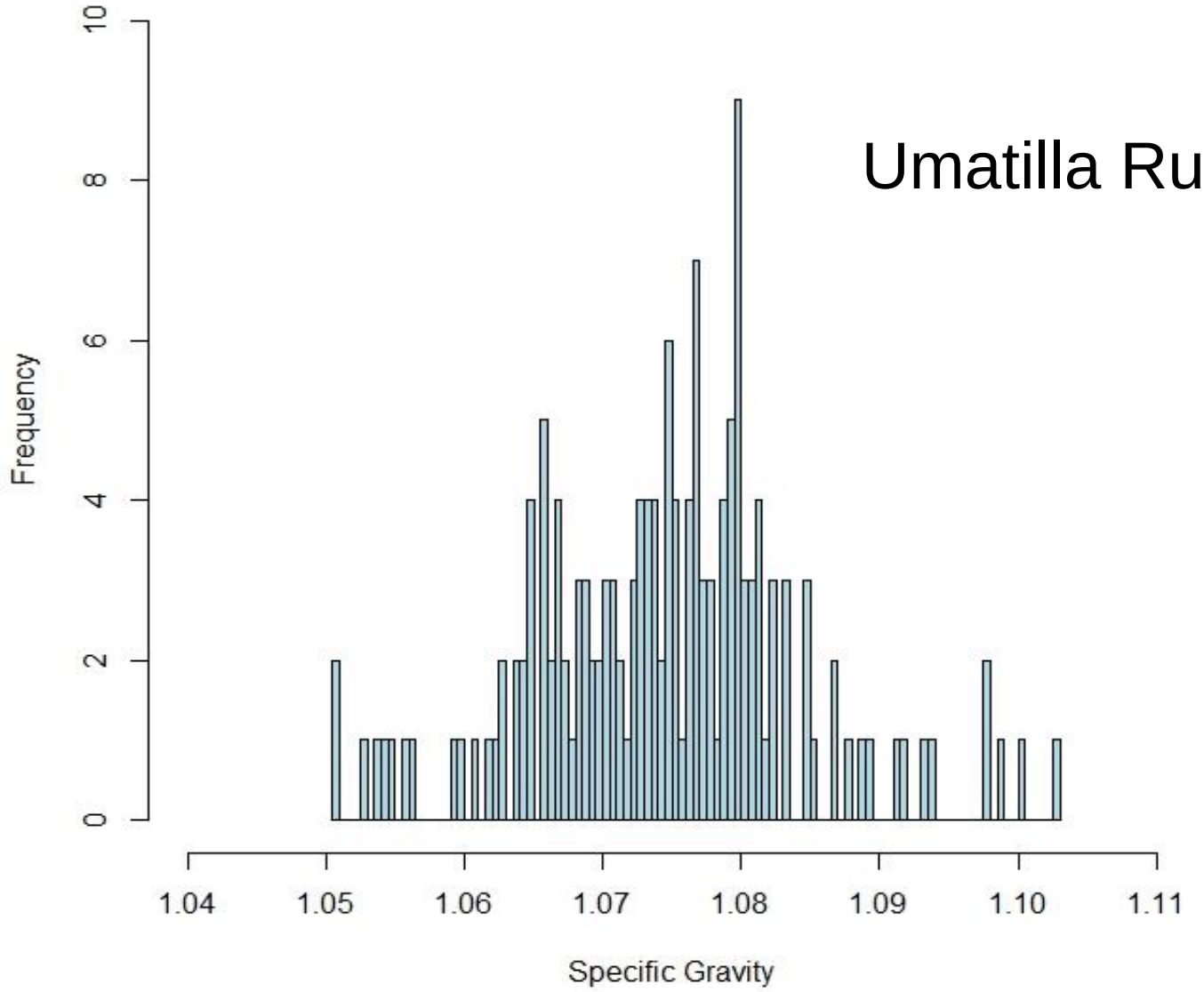
Traits receiving greater attention

Attribute	Total votes	QSR	Processor	Grower
% Sugar ends	14	2	4	8
Bruise free	9	0	4	5
Acrylamide	9	1	5	3
Resist Cold-sweetening	9	1	0	8
Specific gravity	8	2	5	1
Yield	8	1	4	3
Consistent solids	8	2	5	1
Size	7	1	4	2
% high sugar	6	2	2	2
Stores to summer	5	1	3	1

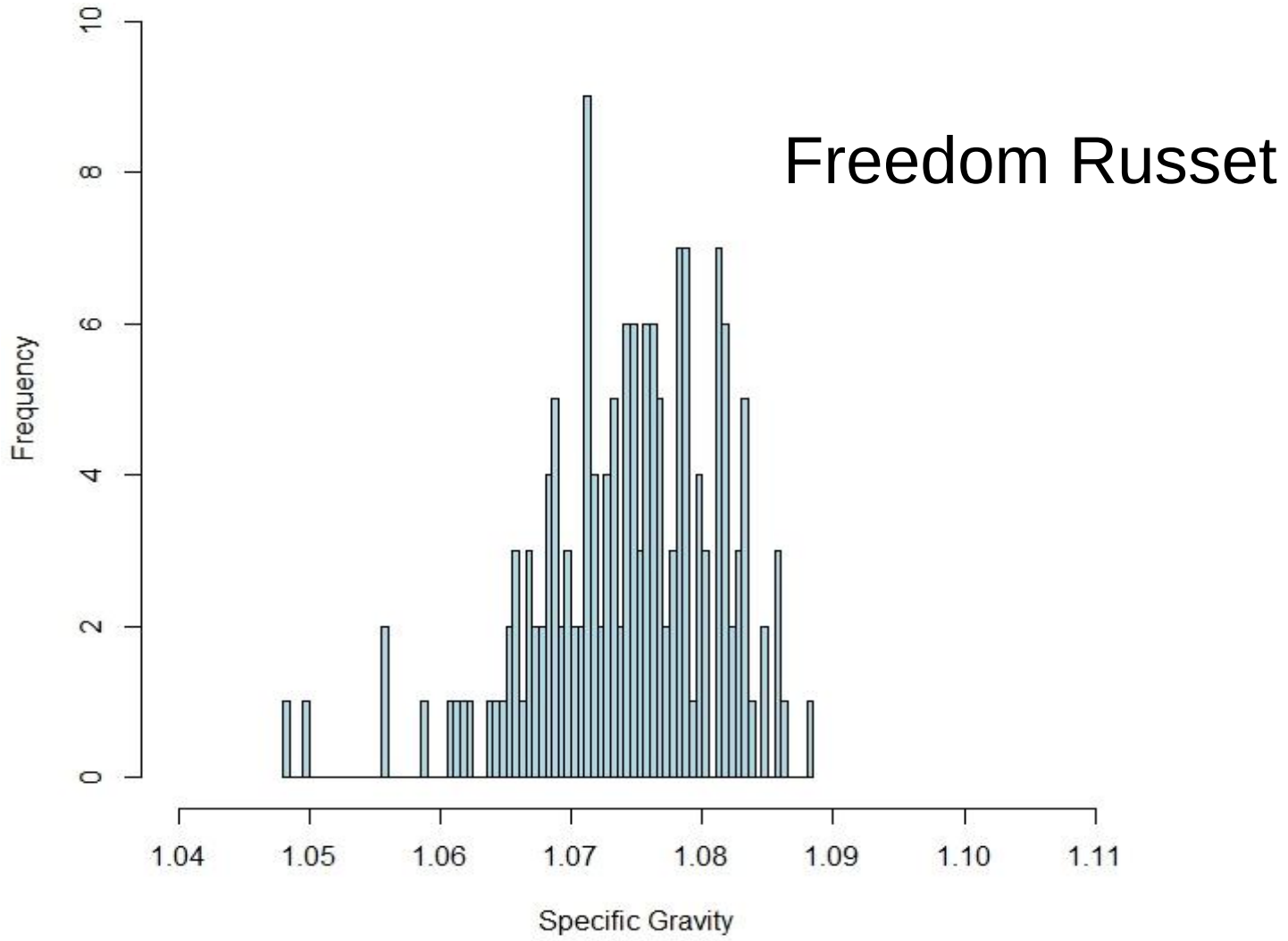
Sugar-end defect screening

- A method to assess sugar ends in material fried at East Grand Forks is being developed
- Lightness of fried slabs from replicated SCRI Agronomic trials will he quantified at bud and stem end

Assessing consistency of solids in SCRI Agronomic trials



Assessing consistency of solids in SCRI Agronomic trials



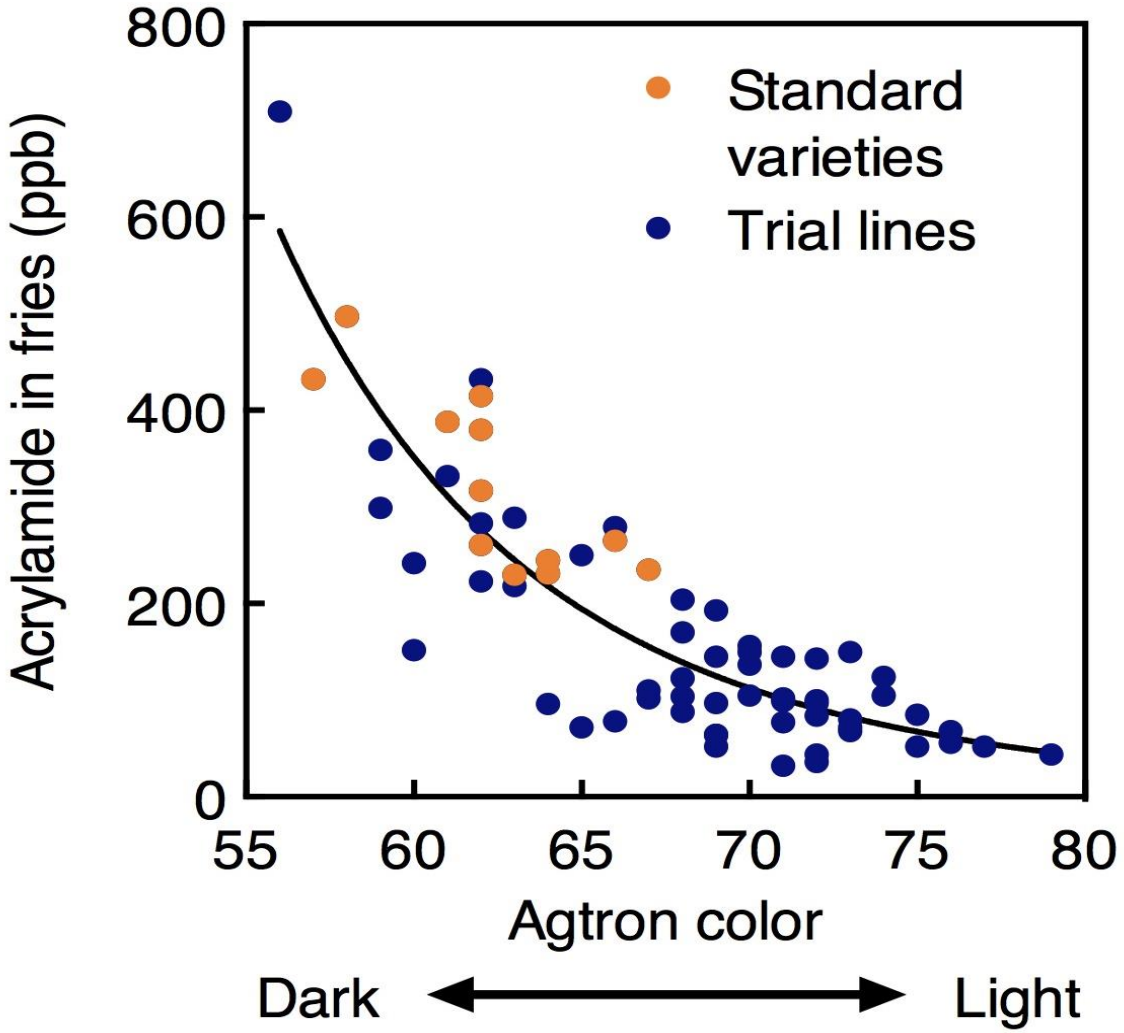
Long term storage is a priority. Are we addressing this properly?

- Few options for storage with sprout inhibitor
- Difficulty planning next season based on May-August data
- Restricted choices. Few clones have low sugars in late storage
- How do we breed for long-term storage? Parents, methods, priorities.

Data analysis – using the data we already have for discussion and planning

- What have we learned so far?
- What don’t we know?
- What can we do better?

Many clones have low acrylamide-forming potential



How likely is it that one variety will meet industry requirements across locations?

- NFPT data from 2011 and 2012
- 3 locations in 2011; 5 locations in 2012
- Specific gravity, % >6 oz weight, % >10 oz weight, glucose, acrylamide
- Two traits were removed from joint probability calculations due to high correlation with other traits

Probability of success in 2011

Rank	Clone	SG	6 oz	Gluc	Joint Probability
1	A02507-2LB	0.9952	0.2568	0.9964	0.2547
2	A0073-2	1.0000	0.2230	0.9778	0.2181
3	AC99375-1RU	0.7667	0.1746	0.9848	0.1319
4	AF4281-3	0.7995	0.1827	0.7042	0.1029
5	MN15620 (MonDak Gold)	0.9128	0.1358	0.7909	0.0981
6	AC96052-1RU	0.9252	0.1052	0.9318	0.0907
7	ND060735-4Russ	0.8993	0.0967	1.0000	0.0870
8	ND8229-3	0.6254	0.1427	0.8531	0.0761
9	W7449-1rus	0.5087	0.1658	0.8578	0.0724
10	AF4320-17	1.0000	0.0700	1.0000	0.0700
11	W8152-1rus	0.5296	0.1407	0.9292	0.0693
12	A02424-83LB	0.7367	0.2650	0.3460	0.0676
13	A02138-2	0.4836	0.1113	1.0000	0.0538
14	ND8068-5Russ	0.9012	0.0624	0.9335	0.0525
15	Alpine Russset	0.8273	0.1749	0.3596	0.0520
16	AF4040-2	0.7086	0.1122	0.5297	0.0421
17	ND049546b-10Russ	0.6766	0.0936	0.6476	0.0410
18	MN02467	0.7133	0.0654	0.8023	0.0374
19	A02060-3TE	1.0000	0.1576	0.2345	0.0370
20	AF3001-6	0.6444	0.0491	0.9973	0.0315
28	Ranger	0.7697	0.5493	0.0612	0.0259
74	Burbank	0.2494	0.1133	0.0001	0.00000383

81 clones tested in 2011
Criteria used:
Specific gravity: 1.080-1.095
%>6oz weight: 68-74%
%>10oz weight: 28-40%
Glucose: 0-0.5 mg/g FW
Acrylamide: 0-250 ppb

In minituber production
In agronomic trials
Both in minituber production and agronomic trials
Checks

Probability of success in 2012

Rank	Clone	SG	6 oz	Gluc	Joint Probability
1	ND8229-3	0.5912	0.1892	0.7295	0.0816
2	A02507-2LB	0.5986	0.1264	0.9817	0.0743
3	W7449-1rus	0.5492	0.1428	0.9002	0.0706
4	ND071387C-2Russ	0.9983	0.1222	0.4510	0.0550
5	W8152-1rus	0.5459	0.1341	0.6913	0.0506
6	AO02183-2	0.5044	0.1122	0.8814	0.0499
7	AF3001-6	0.4596	0.1671	0.6369	0.0489
8	GemStar Russet	0.5500	0.1034	0.7107	0.0404
9	A02138-2	0.6344	0.1110	0.5518	0.0389
10	AC99375-1RU	0.4709	0.0911	0.8119	0.0348
11	A0012-5	0.3790	0.1767	0.5098	0.0341
12	ND060735-4Rus	0.6155	0.0790	0.6791	0.0330
13	AF3317-15	0.5396	0.2475	0.2323	0.0310
14	A0073-2	0.6731	0.0818	0.5552	0.0306
15	ND071078B-1Russ	0.6609	0.1366	0.3372	0.0305
16	Clearwater Russet	0.4401	0.1553	0.4026	0.0275
17	W9162-3rus	0.3702	0.0808	0.8779	0.0262
18	AF3008-3	0.6841	0.1618	0.2187	0.0242
19	W9604-1rus	0.3487	0.0709	0.8504	0.0210
20	AO96141-3	0.4784	0.1214	0.3566	0.0207
49	Ranger	0.4831	0.1117	0.1491	0.0080
53	Burbank	0.3187	0.1201	0.1900	0.0073

88 clones tested in 2012
Criteria used:
Specific gravity: 1.080-1.095
%>6oz weight: 68-74%
%>10oz weight: 28-40%
Glucose: 0-0.5 mg/g FW
Acrylamide: 0-250 ppb

In minituber production

In agronomic trials

Both in minituber production and agronomic trials

Checks

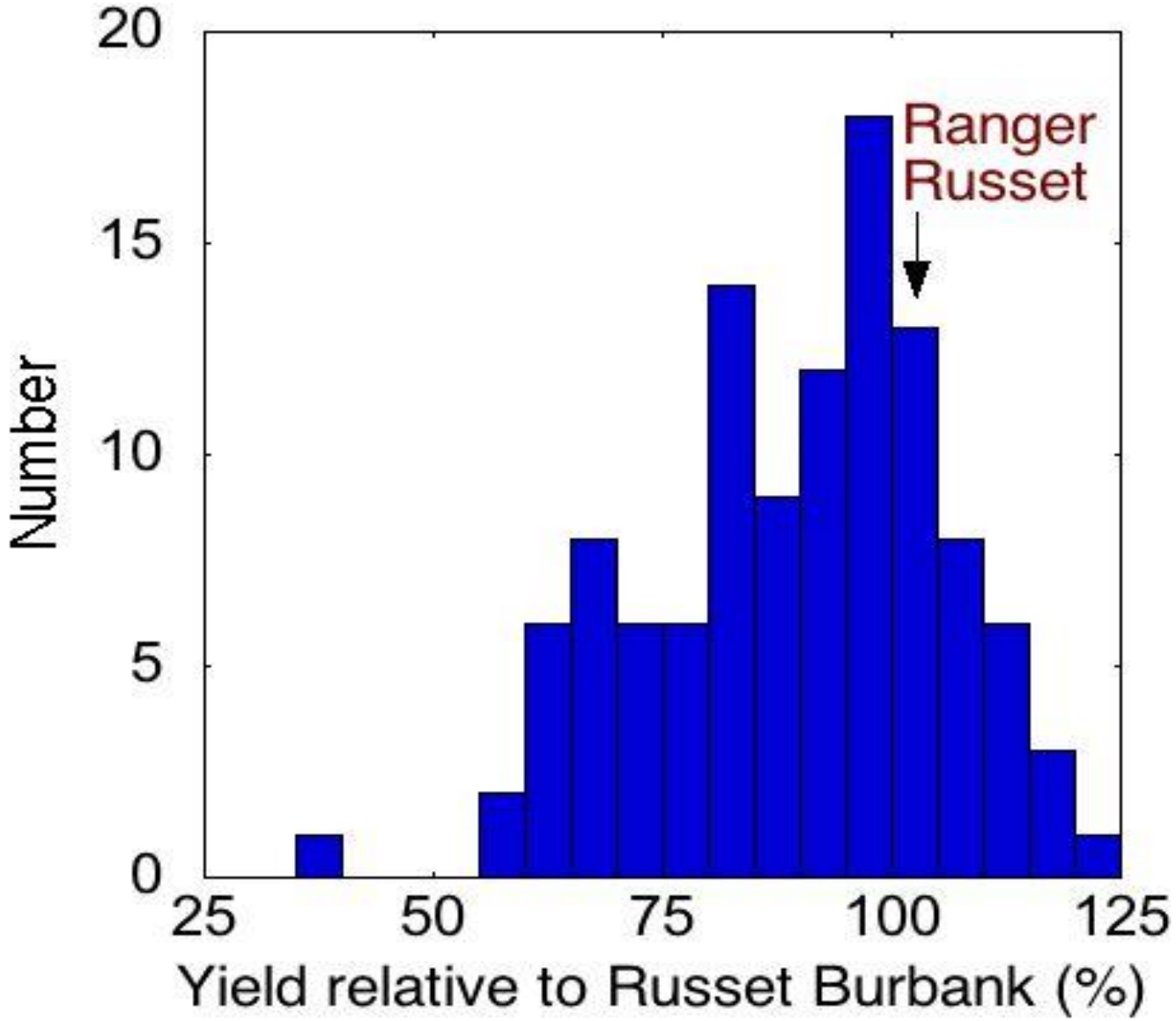
Joint probability rank in NFPT for varieties in NFT or seed production

Clone	Joint probability rank in 2011	Joint probability rank in 2012
ND8229-3	8	1
AC96052-1RU	6	27
W6234-4rus	79	65
AF4296-3	69	38
A02507-2LB	1	2
A02138-2	13	9

Refining yield estimations to more efficiently screen clones

- Data from replicated plots in SCRI Agronomic trials
- Do NFPT data provide useful estimates of yield?

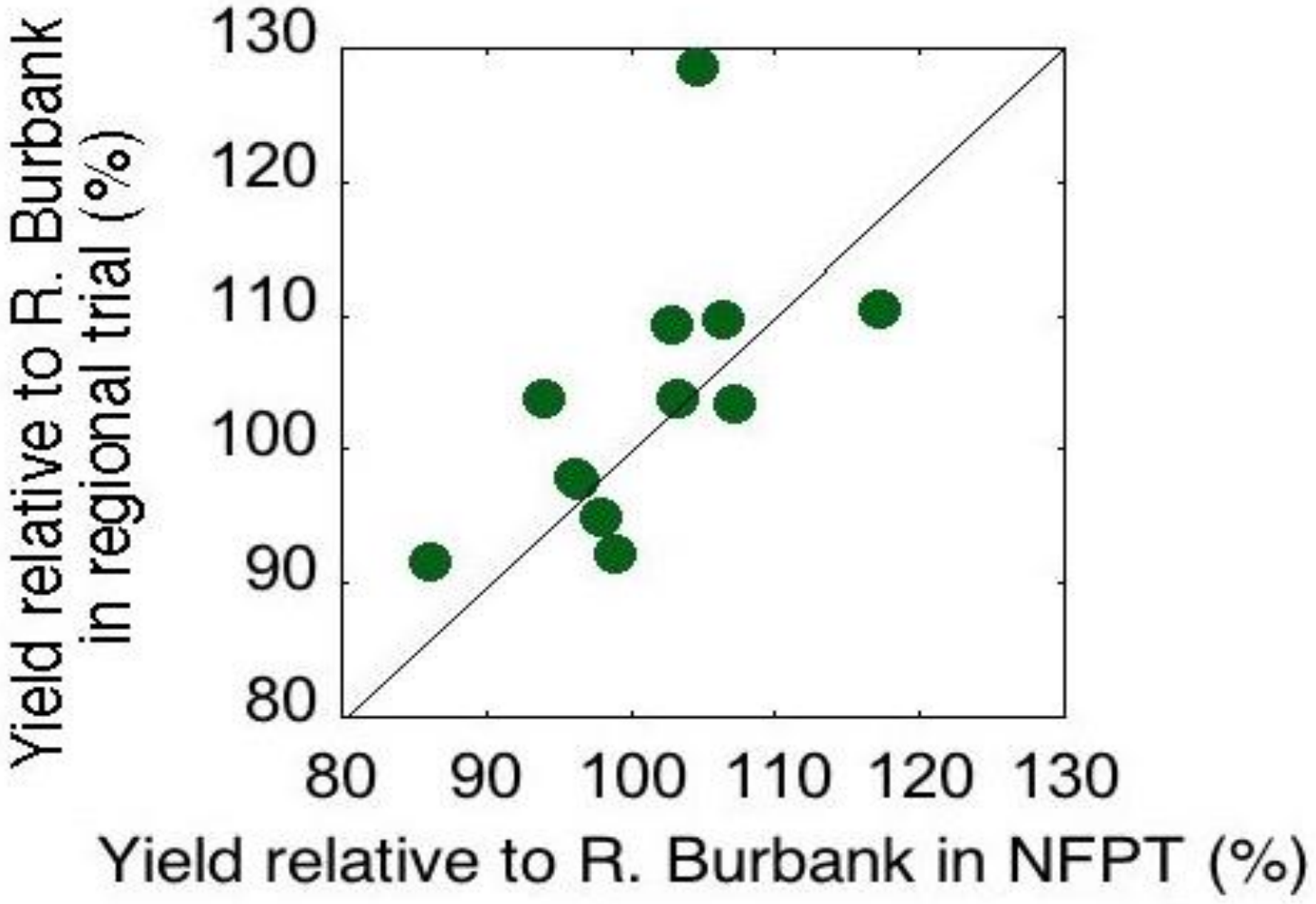
Total yield of clones in NFPT



Highest yielding clones in NFPT

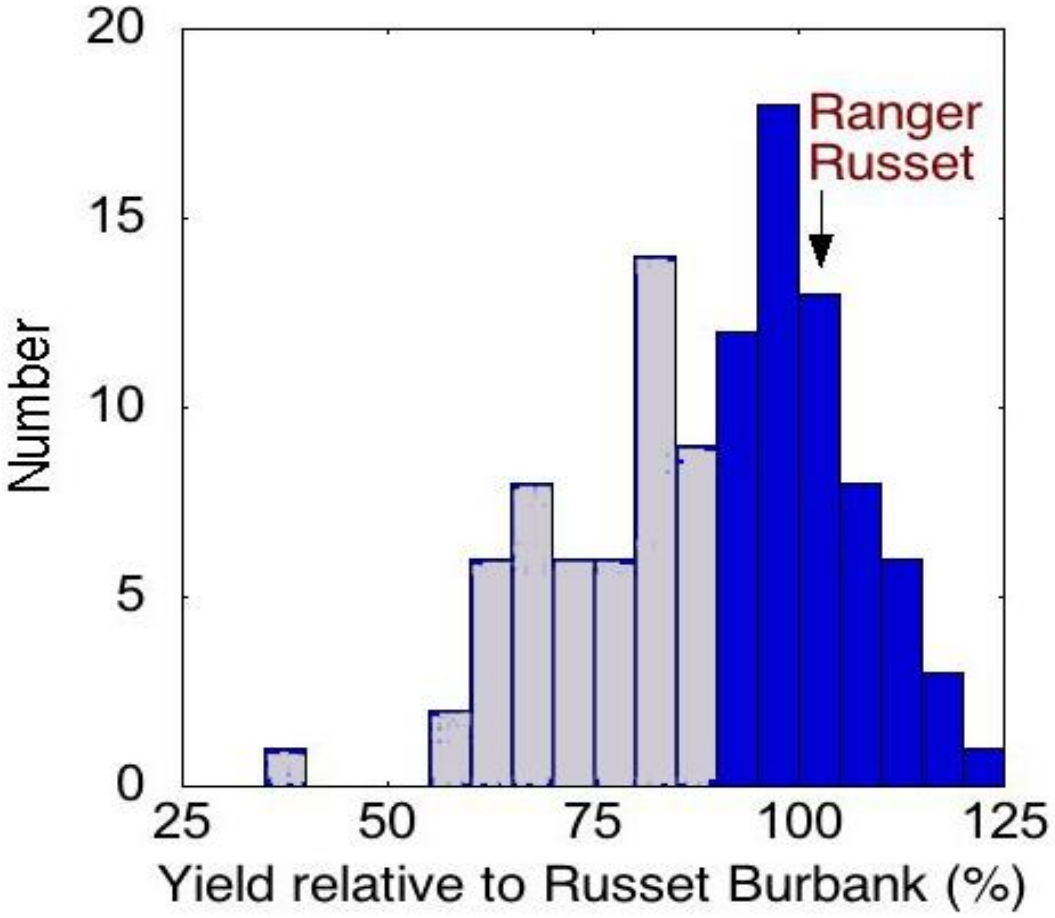
Breeder ID number	Average Yield
AC99375-1RU	119
AO02183-2	119
A9305-10	116
ND060742C-1Russ	115
ND049289-1Russ	112
AF4347-1	112
AF3001-6	112
AF4342-3	111
AO96141-3	110
A01325-1	110
Agila	109
CO97087-2RU	109
AO82611-7	108
A01025-4	108
W1836-3rus	107
AF4296-3	107
ND049423b-1Russ	106
AC00395-2RU	105
A03921-2	105
A82360-7	104
AR98-9	104
ND071078B-1Russ	103
A01010-1	103
A7411-2	102
A02424-83LB	102
AND99362-1Russ	101
AF4124-7	101
A9045-7	100
MN15620	99
W9604-1rus	99
AOA95154-1	99
Russet Burbank	99

Relative yield of varieties in NFPT compared with other regional trials



Low yields increase costs and decrease profit potential

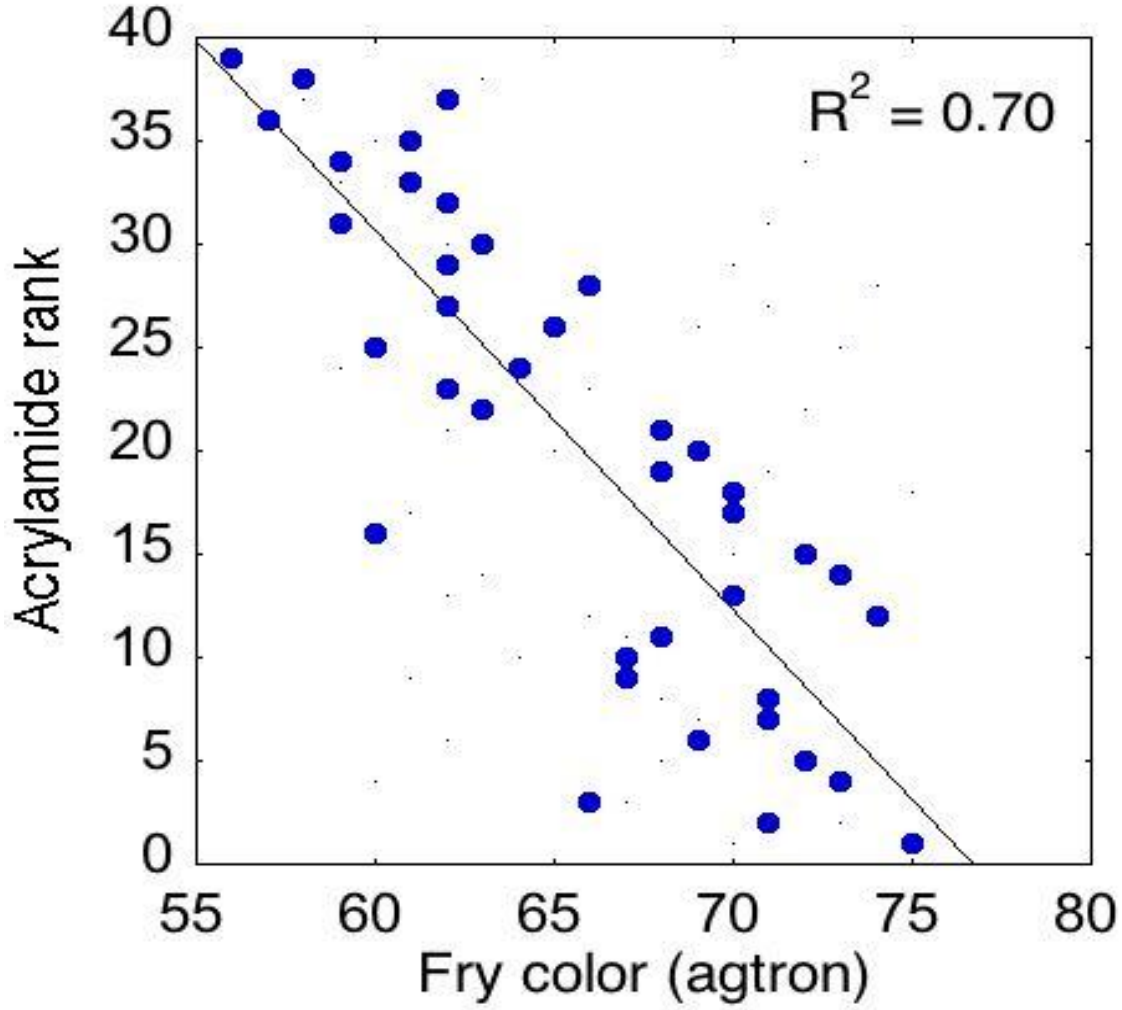
Should we invest resources in clones that yield less than 90% of Russet Burbank?



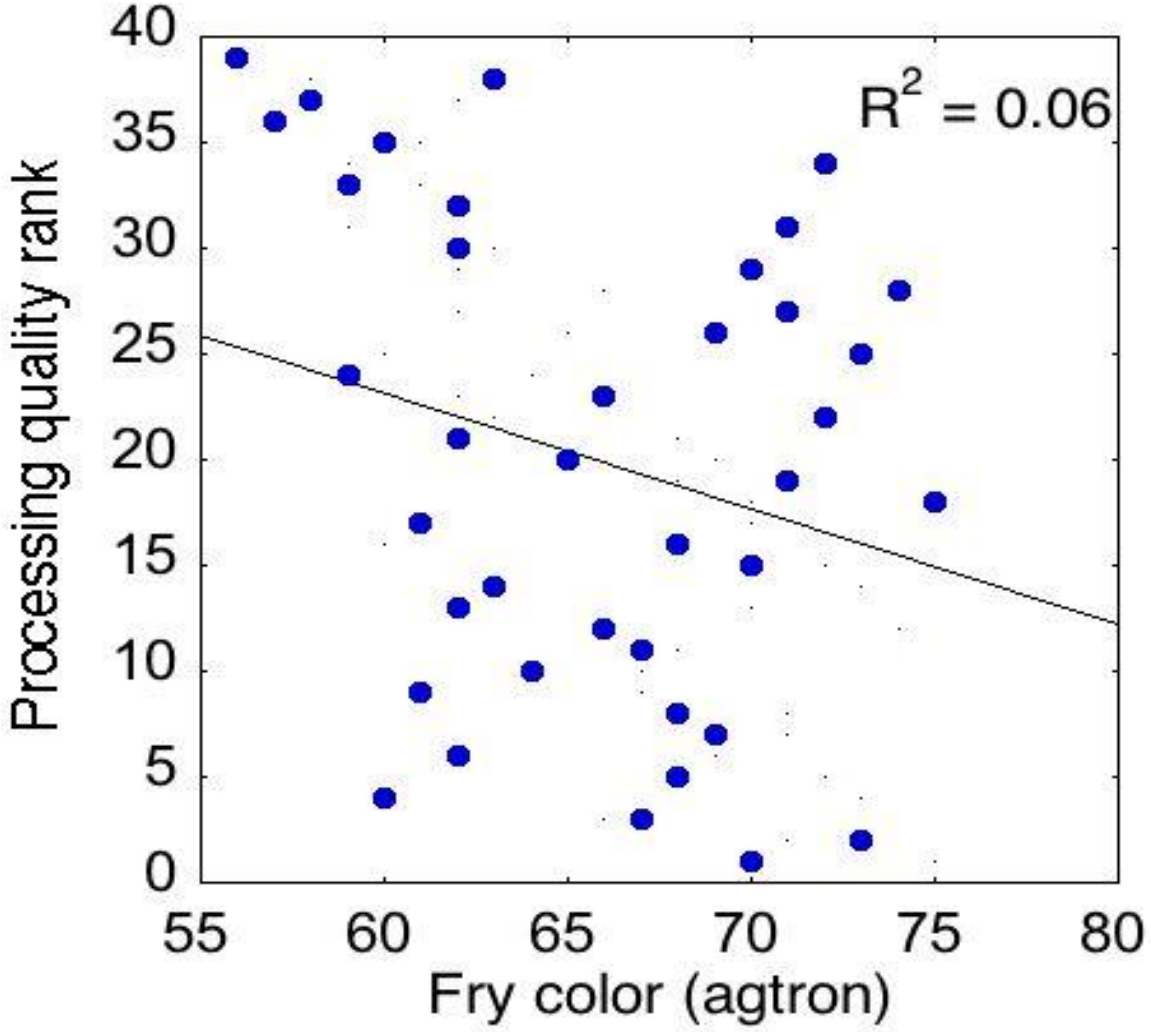
Developing an estimate for fry processing quality

- Useful for assessing trial clones
- Minimal training requirements
- Uses available facilities
- Incorporate processor and end-user criteria sooner in the decision making process

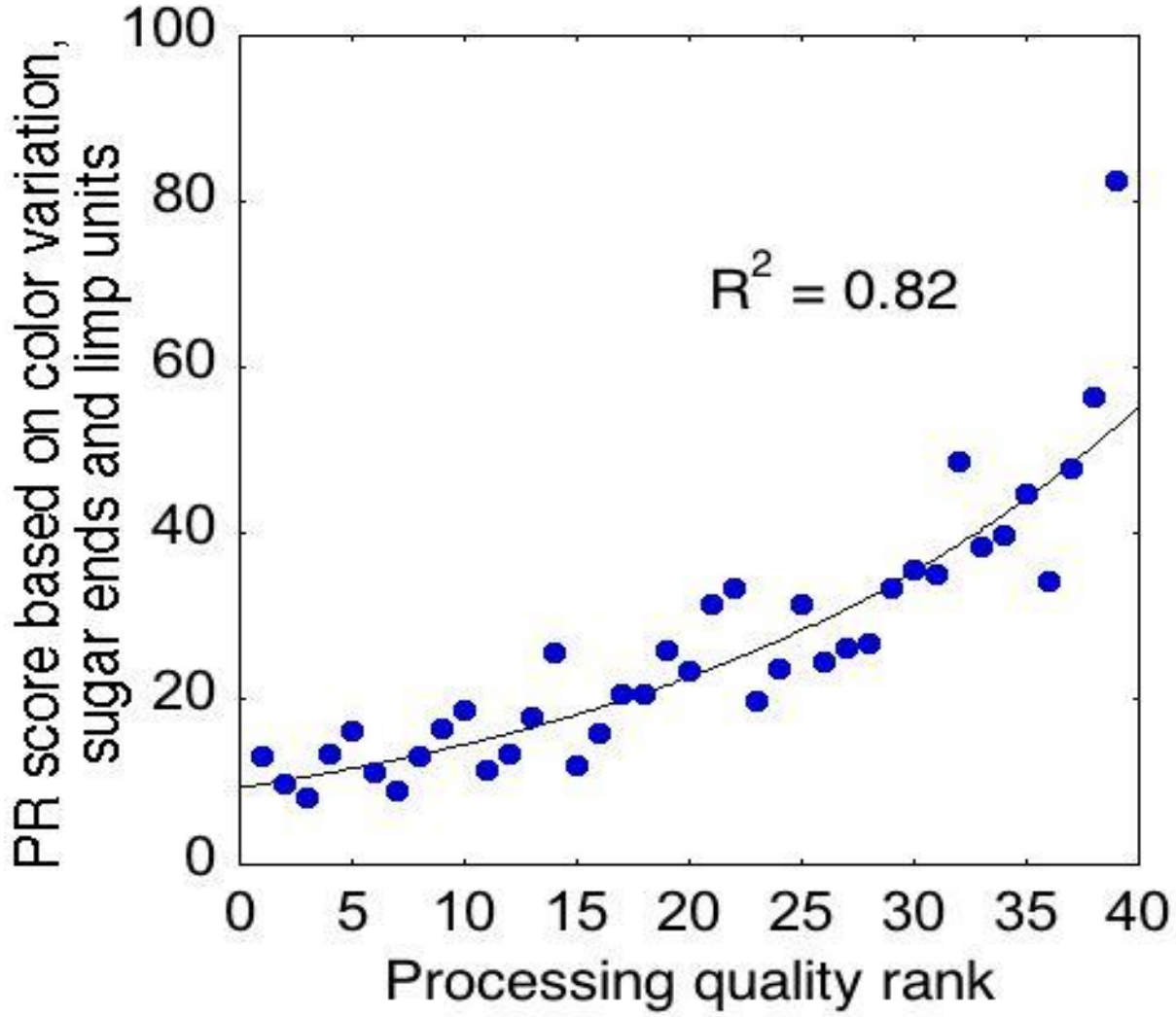
Fry color is a good predictor of acrylamide rank…



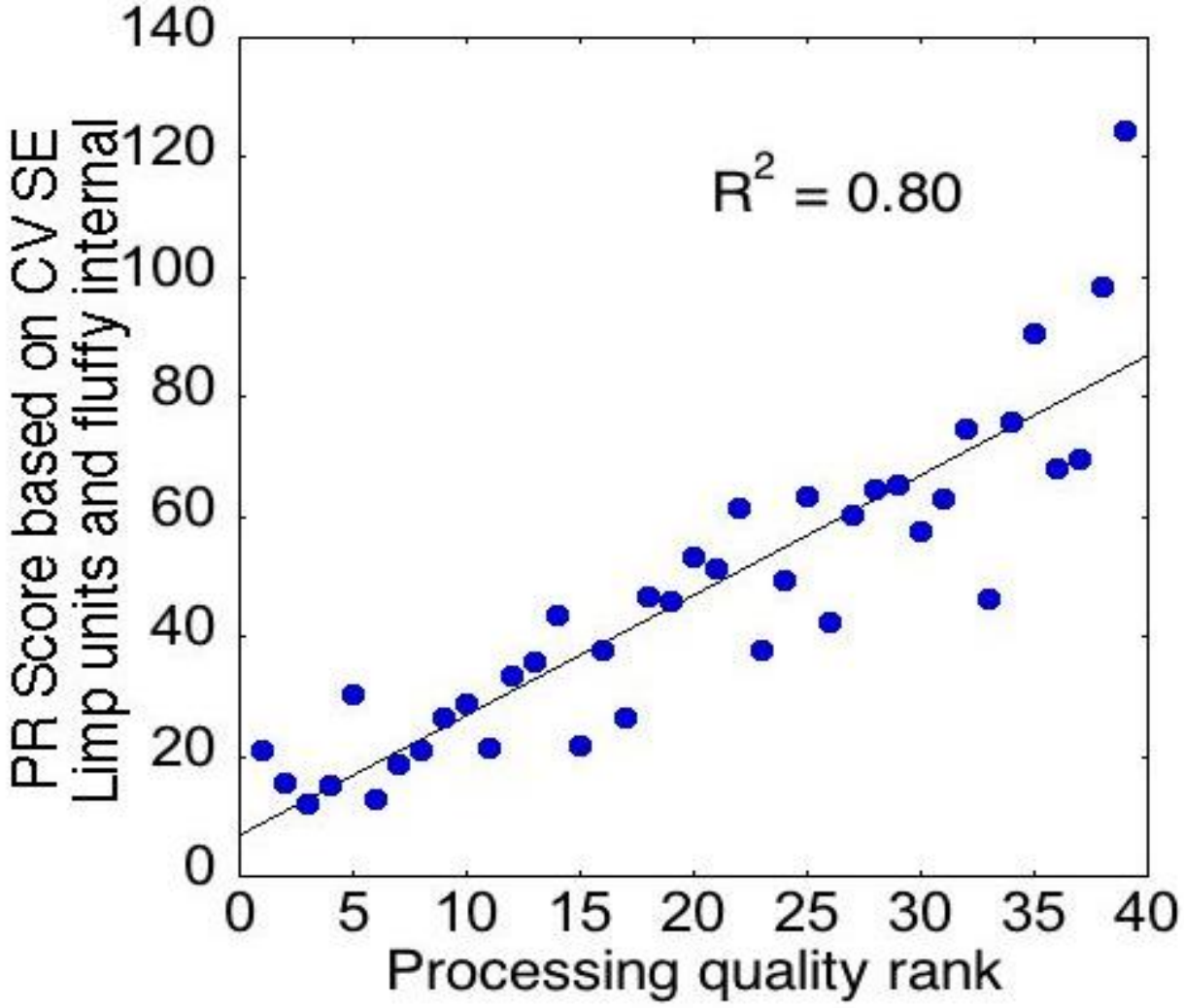
…but not a good predictor of processing quality rank



A QA estimate based on three easily scored parameters



A QA estimate based on four parameters



Improving the decision making process

- What assessments need to be included in agronomic trials
- Selection of lines for seed increase. How should we make decisions?
- How much asparagine and acrylamide testing is needed and for what samples?
- How do we assess long-term storage potential?
- Can we cover seed production costs?

Future NFPT and SCRI trials

- Where can we make improvements?
- Where can we reduce expenditures or decrease effort?
- Where is greater effort needed?
- Can we maximize value from existing data by including regional trials in assessments

Thanks

Why are we doing multi-site variety evaluations?

Breeders develop clones best suited for local conditions.

…or do they?

Breeder merit for 2012 NFPT

Breeding Program	Trial site				
	ID	ME	ND	WA	WI
ID	2.3 + 0.8		2.1 + 0.2	2.6 + 0.8	2.2 + 0.8
ME	2.6 + 1.0	2.4 + 0.8	2.0 + 0.6	3.1 + 0.9	2.5 + 0.9
ND	3.3 + 1.1	3.3 + 1.0	1.8 + 0.9	3.0 + 1.3	3.0 + 1.0
OR	2.4 + 1.4		2.1 + 0.9	2.9 + 0.9	2.2 + 1.0
WI	3.2 + 0.9	3.4 + 0.9	1.8 + 0.7	3.5 + 0.8	2.8 + 0.9
CO	3.0 + 0.9	2.9 + 0.8	2.1 + 0.3	3.3 + 0.7	2.2 + 0.6

Breeder merit for 2012 NFPT

Breeding Program	Trial site				
	ID	ME	ND	WA	WI
ID	2.3 + 0.8		2.1 + 0.2	2.6 + 0.8	2.2 + 0.8
ME	2.6 + 1.0	2.4 + 0.8	2.0 + 0.6	3.1 + 0.9	2.5 + 0.9
ND	3.3 + 1.1	3.3 + 1.0	1.8 + 0.9	3.0 + 1.3	3.0 + 1.0
OR	2.4 + 1.4		2.1 + 0.9	2.9 + 0.9	2.2 + 1.0
WI	3.2 + 0.9	3.4 + 0.9	1.8 + 0.7	3.5 + 0.8	2.8 + 0.9
CO	3.0 + 0.9	2.9 + 0.8	2.1 + 0.3	3.3 + 0.7	2.2 + 0.6

Specific gravity for 2012 NFPT

Breeding Program	Trial site				
	ID	ME	ND	WA	WI
ID	1.081		1.096	1.088	1.075
ME	1.077	1.082	1.087	1.087	1.073
ND	1.085	1.083	1.100	1.085	1.077
OR	1.082		1.093	1.089	1.077
WI	1.086	1.101	1.074	1.081	1.069
CO	1.084	1.089	1.079	1.091	1.077

Specific gravity for 2012 NFPT

Breeding Program	Trial site				
	ID	ME	ND	WA	WI
ID	1.081		1.096	1.088	1.075
ME	1.077	1.082	1.087	1.087	1.073
ND	1.085	1.083	1.100	1.085	1.077
OR	1.082		1.093	1.089	1.077
WI	1.086	1.101	1.074	1.081	1.069
CO	1.084	1.089	1.079	1.091	1.077

Mid-season tuber glucose for 2012 NFPT

Breeding Program	Trial site				
	ID	ME	ND	WA	WI
ID	0.2		0.4	0.7	1.3
ME	1.4	0.3	0.5	0.8	1.9
ND	0.3	0.2	0.2	0.4	0.8
OR	0.5		0.4	0.7	1.2
WI	0.1	0.1	0.3	0.2	0.5
CO	0.2	0.3	1.3	1.0	2.3

Mid-season tuber glucose for 2012 NFPT

Breeding Program	Trial site				
	ID	ME	ND	WA	WI
ID	0.2		0.4	0.7	1.3
ME	1.4	0.3	0.5	0.8	1.9
ND	0.3	0.2	0.2	0.4	0.8
OR	0.5		0.4	0.7	1.2
WI	0.1	0.1	0.3	0.2	0.5
CO	0.2	0.3	1.3	1.0	2.3

Clone selection at Potato Expo for NFT minituber production

NFPT minituber production

Clone	State				2011	2012
	ID	ME	WA	WI	QSR	QSR
ND8229-3					3	4
AC96052-1rus					3	1
W6234-4rus					3	1
AF4296-3					3	1
A02507-2LB					2	1
AF3001-6					3	3
A02138-2						1
AO01114-4						1
A0012-5					3	2
A0073-2					3	
A03921-2						
AC00395-2Ru						
AC99375-1Ru						
AF4342-3					3	
AO00057-2						
AO02183-2						1
Dakota Trailblazer					3	
ND049423b-1Russ						
ND060735-4Russ					3	
W7449-1rus						
W8152-1rus						
W9604-1Rus						

	Liked
	Disliked
	Not tested or mixed result