Nitrogen Management Effects on Tuber Yield, Quality, and Acrylamide Content of Five Processing Cultivars

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UNIVERSITY OF MINNESOTA
EXTENSION

Background

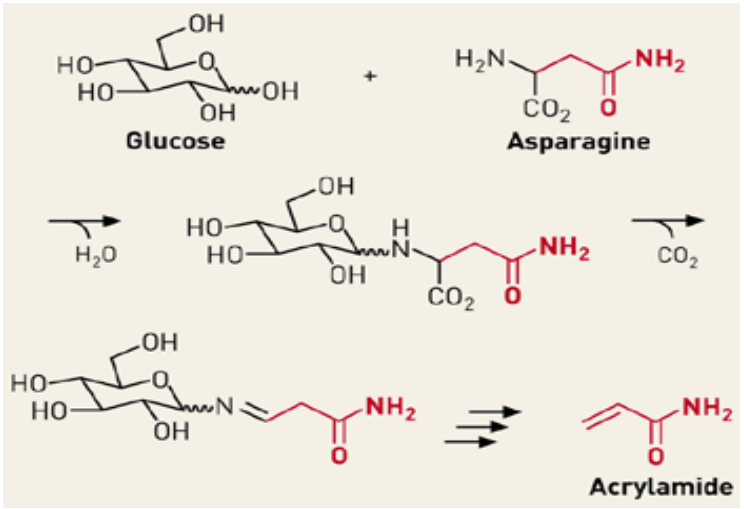
- Two years of funding from the USDA Specialty Crop Block Grant program
  - “enhance the competitiveness of specialty crops”
  - Funds are administered through the state Ag departments
- Joint project between MN and NDSU using similar treatments and varieties
- Conducted in 2011 and 2012

Acrylamide

- A compound formed during potato processing (fries and chips)
- A suspected carcinogen
- Fries and chips are among the highest contributors to acrylamide
- WHO – “appropriate efforts to reduce acrylamide concentrations in food should continue”

Acrylamide formation

- Acrylamide is formed by the Maillard reaction during frying from two precursors:
  - Reducing sugars (such as glucose & fructose)
  - The amino acid asparagine



http://pubs.acs.org/cen/topstory/8040/8040notw2.html

- Higher temperatures during processing also increase acrylamide (>375 F)

Acrylamide formation

- Acrylamide can potentially be minimized by reducing the concentrations of the precursors
  - Nitrogen is a component of asparagine
  - Nitrogen also can affect glucose concentrations
- Sucrose, glucose, and asparagine are influenced by genetic and environmental factors
  - Cultivar
  - Field conditions
  - Storage conditions

Objectives

- To determine the effects of cultivar and nitrogen regime on potato yield and tuber quality
- To determine the effect of variety, nitrogen regime, and storage time on concentrations of acrylamide precursors in tubers and acrylamide in fried potato products
- To determine relationships between tuber acrylamide precursors and tuber acrylamide formation

Methods

- 5 N treatments: 30, 120, 180, 240, 300 lb N/A
  - 30 lb starter + ESN at emergence at Becker
  - 30 lb starter + Urea splits at Inkster
- 5 varieties: Russet Burbank, Alpine Russet, Dakota Trailblazer, Snowden, Ivory Crisp
- 4 Replications; 4, 20’ rows, harvested the middle two rows
- Conducted in 2011 and 2012

Methods

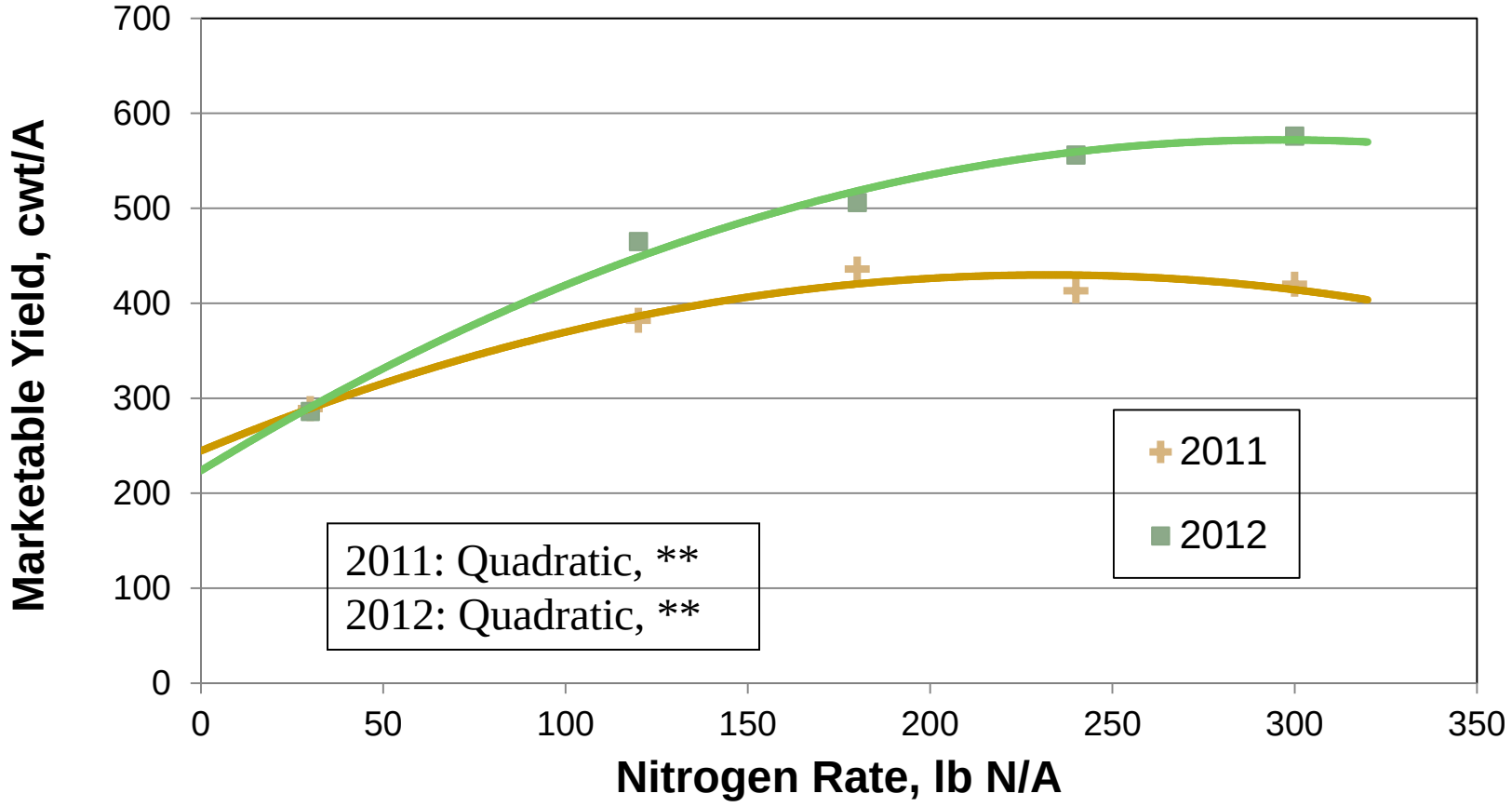
- Two locations
  - Becker, MN in 2011 and 2012
  - Inkster, ND in 2011 and Park Rapids, MN in 2012
- Becker specifics
  - Planting dates - May 3, 2011 and April 12, 2012
  - Tuber harvest - Sept. 29, 2011 and Oct. 2, 2012
- Inkster specifics (only tuber quality for 2011 presented):
  - Planting date - June 2, 2011
  - Harvest date - October 6, 2011

Measurements

- Yield - only Becker presented for 2011 & 2012
- Tuber Quality – only 2011 for MN and ND
  - 0, 3, 6, and 9 months storage at 46 F
    - Sucrose
    - Glucose
    - AGT for Chips
    - Acrylamide
- Sugars and AGT measured by USDA/ARS, EGF
- Acrylamide measured at the U of M Mass Spectroscopy lab in St. Paul

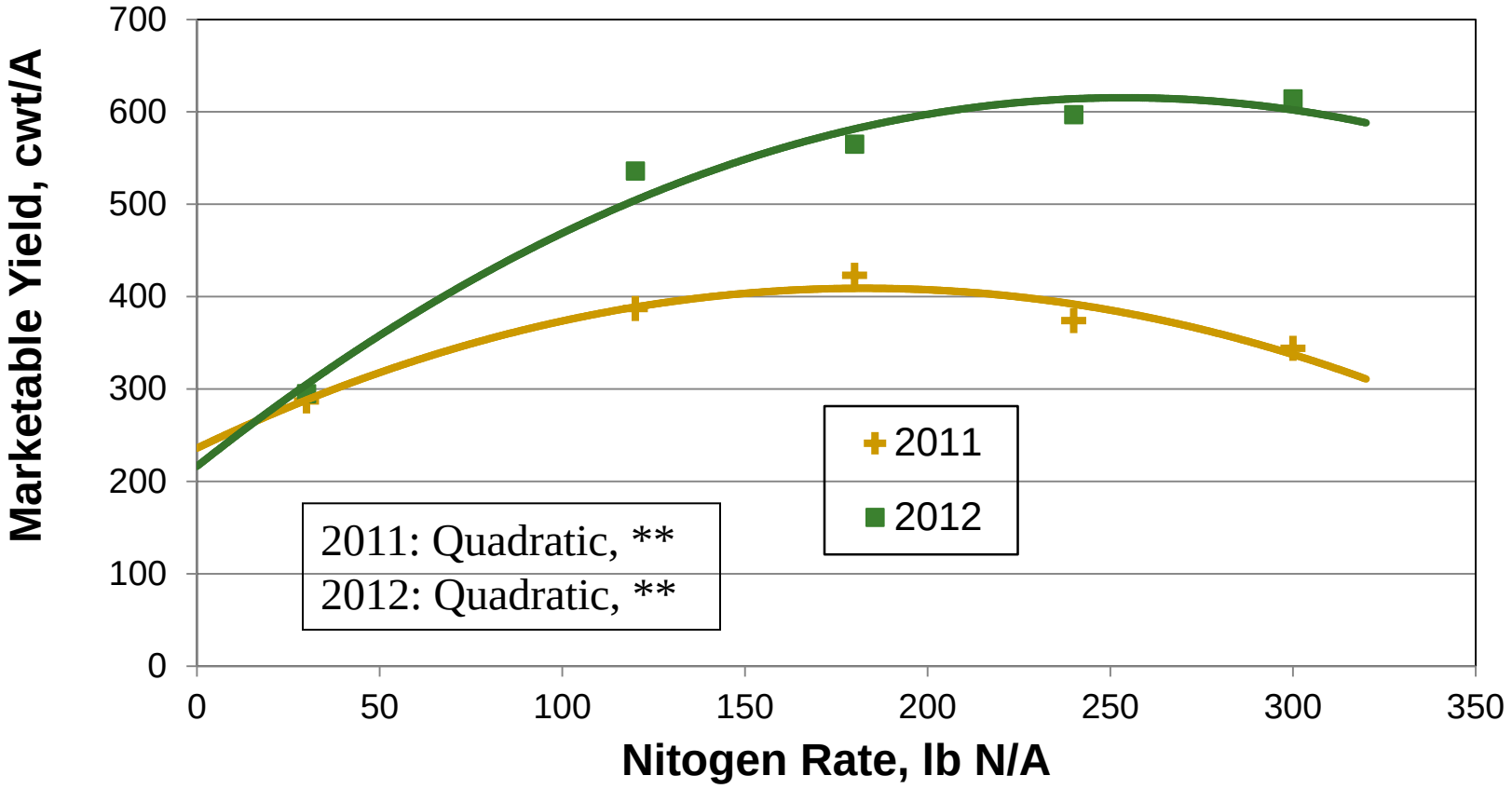
Russet Burbank Response to N

Becker, MN (2011 & 2012)



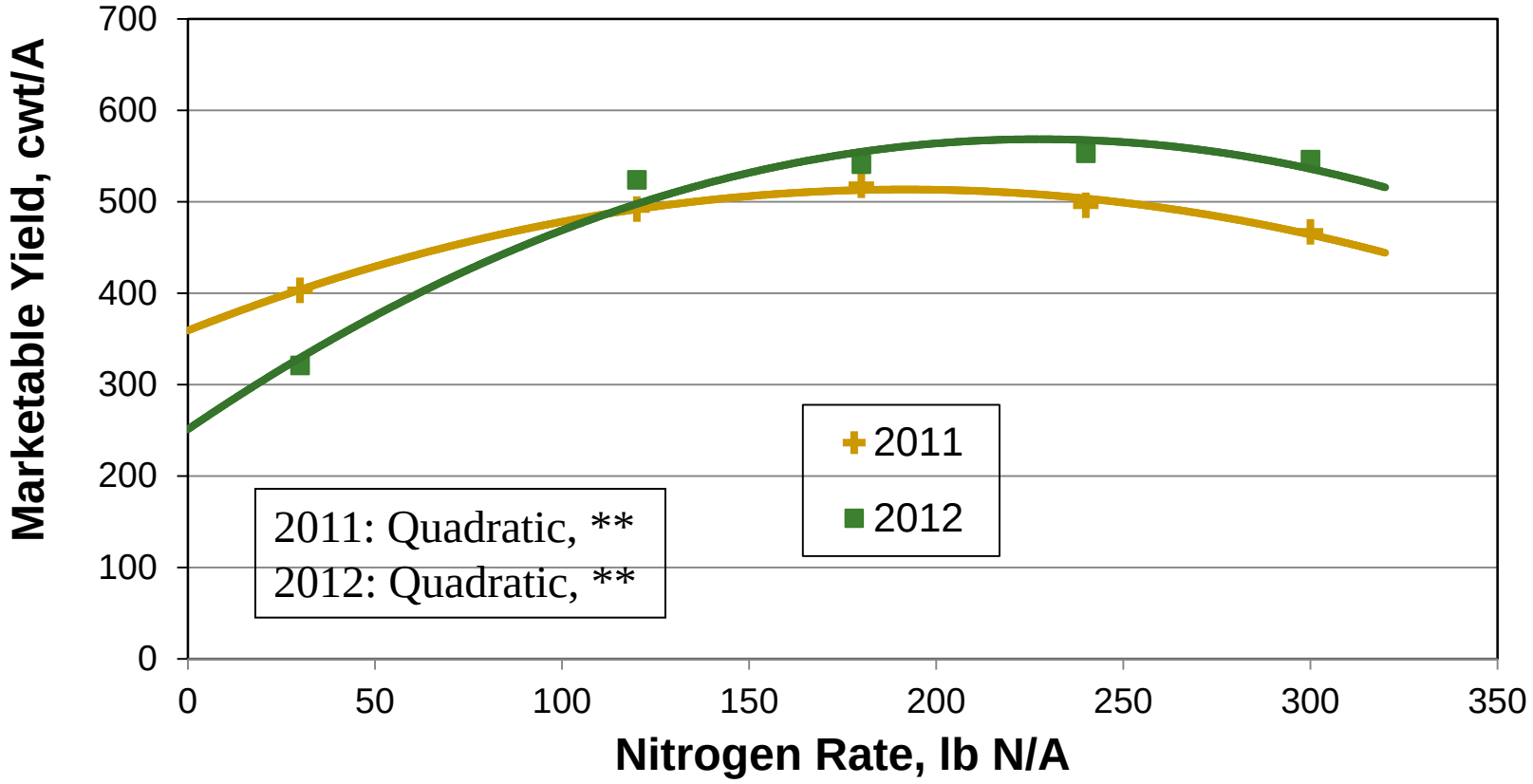
Alpine Russet Response to N

Becker, MN (2011 & 2012)



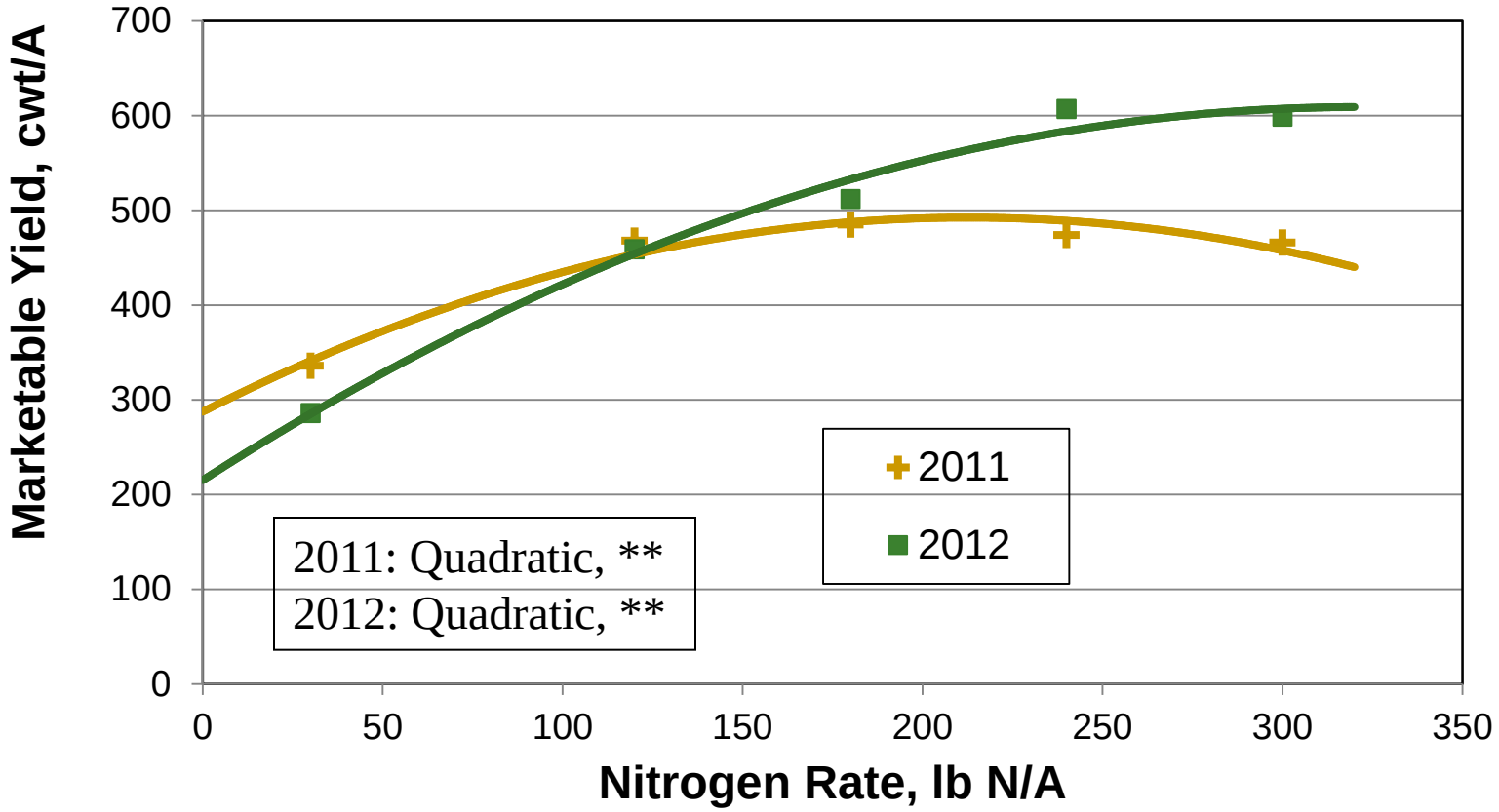
Dakota Trailblazer Response to N

Becker, MN (2011 & 2012)



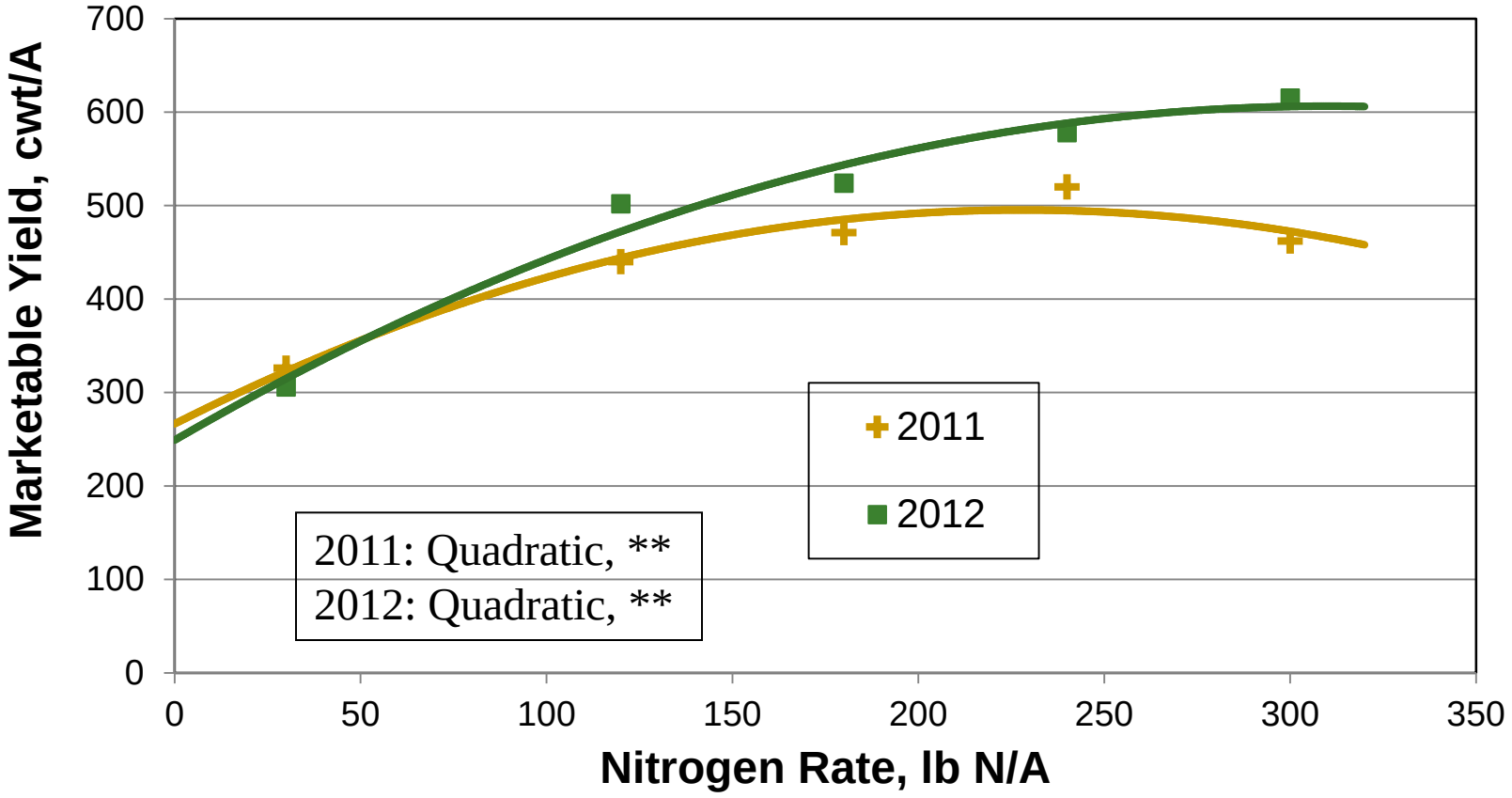
Snowden Response to N

Becker, MN (2011 & 2012)

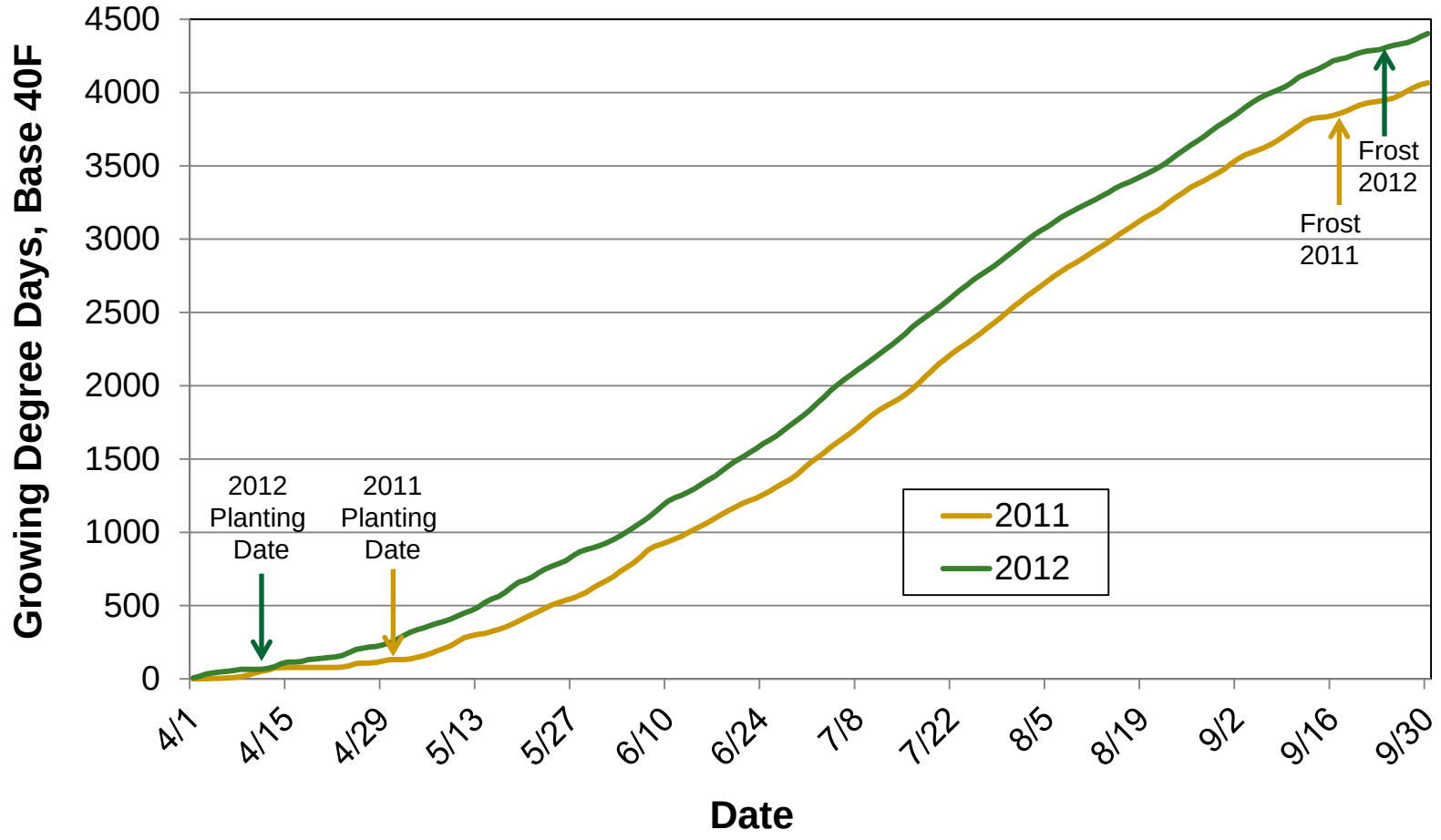


Ivory Crisp Response to N

Becker, MN (2011 & 2012)



Growing Degree Days:2011 vs. 2012



Nitrogen Response Summary

- Yield potential was 50 to 200 cwt/A higher in 2012 than in 2011
- Response to nitrogen was higher in 2012 than in 2011
  - 180-240 lb N/A in 2011 vs. 240-300 lb N/A in 2012
  - Dakota Trailblazer was least responsive to N
- Yield potential and N responses difference were likely due to differences in length of the growing season

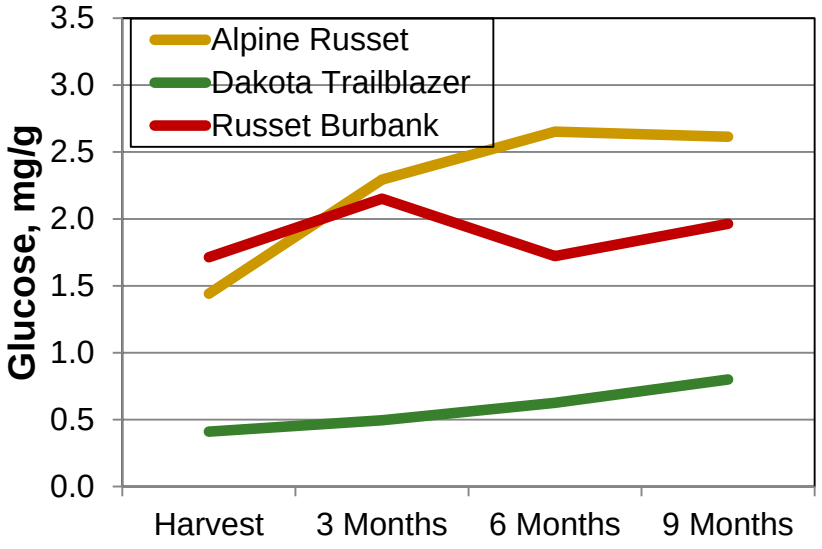
Sucrose, Glucose, and Acrylamide

- Sucrose, glucose and acrylamide concentrations were affected by cultivar, storage time, nitrogen application rate and location
- Response to N and storage varied among cultivars as well as location
- Numerous interactions were significant

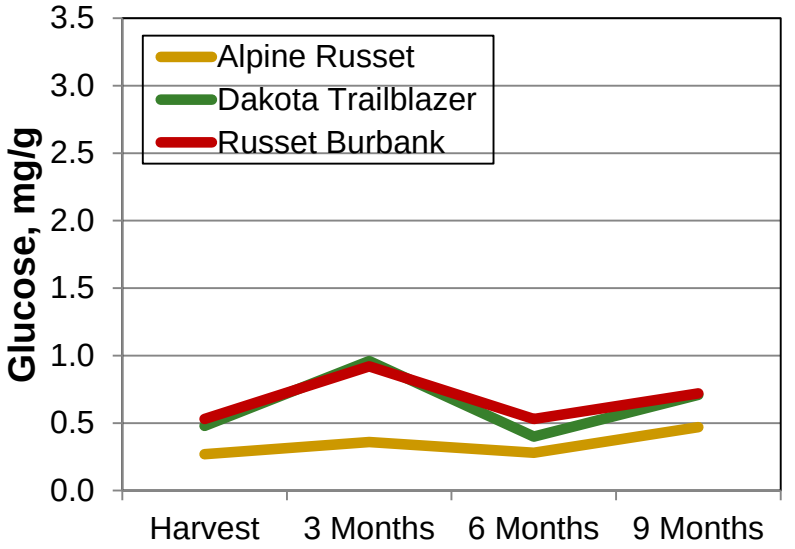
Cultivar by Storage Effects - Glucose

- Frying Cultivars -

Becker, MN



Inkster, ND

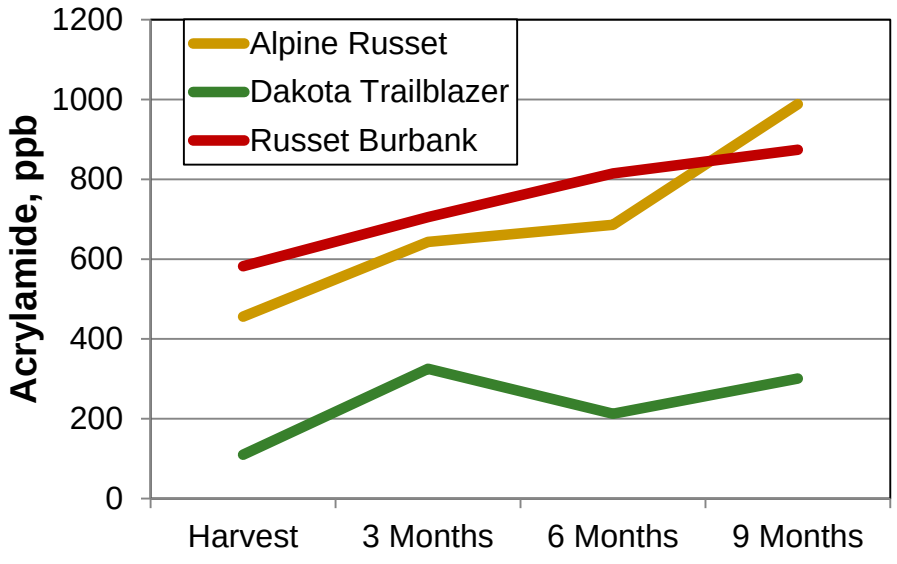


Becker – glucose lower in DT than AR and RB; slight increase with storage
Inkster – glucose lower than at Becker for AR and RB, but not DT

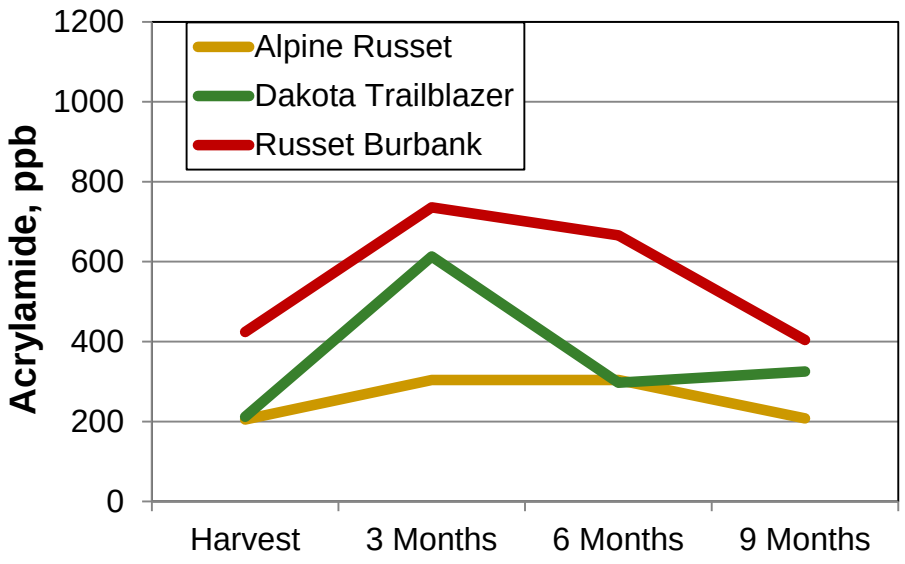
Cultivar by Storage Effects - Acrylamide

- Frying Cultivars -

Becker, MN



Inkster, ND



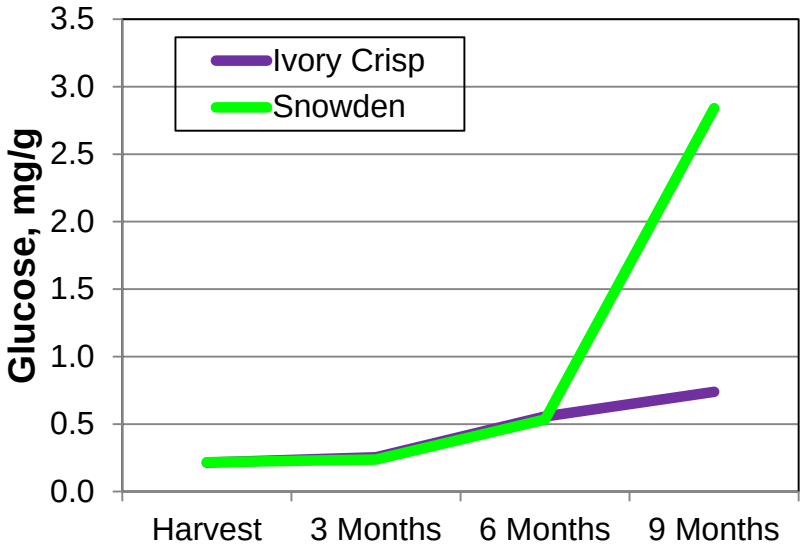
Becker – acrylamide lower in DT than AR and RB; slight increase with storage

Inkster – acrylamide lowest in AR; highest in RB; DT acrylamide higher than at Becker

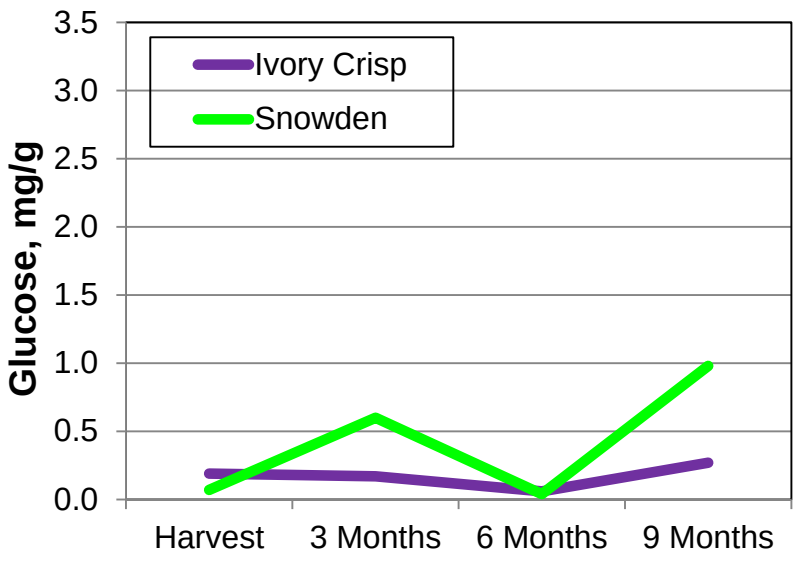
Cultivar by Storage Effects - Glucose

- Chipping Cultivars -

Becker, MN



Inkster, ND

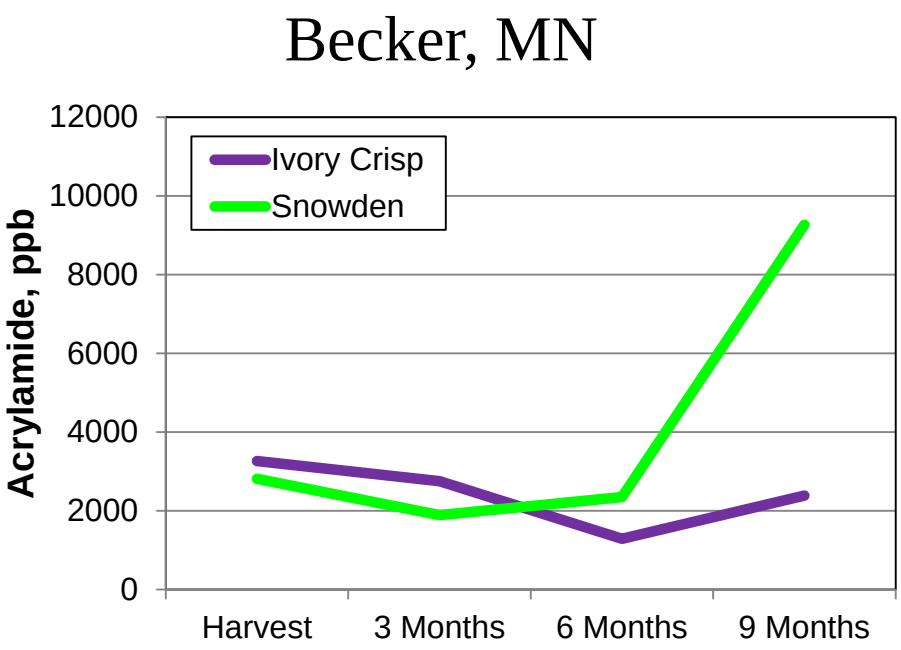


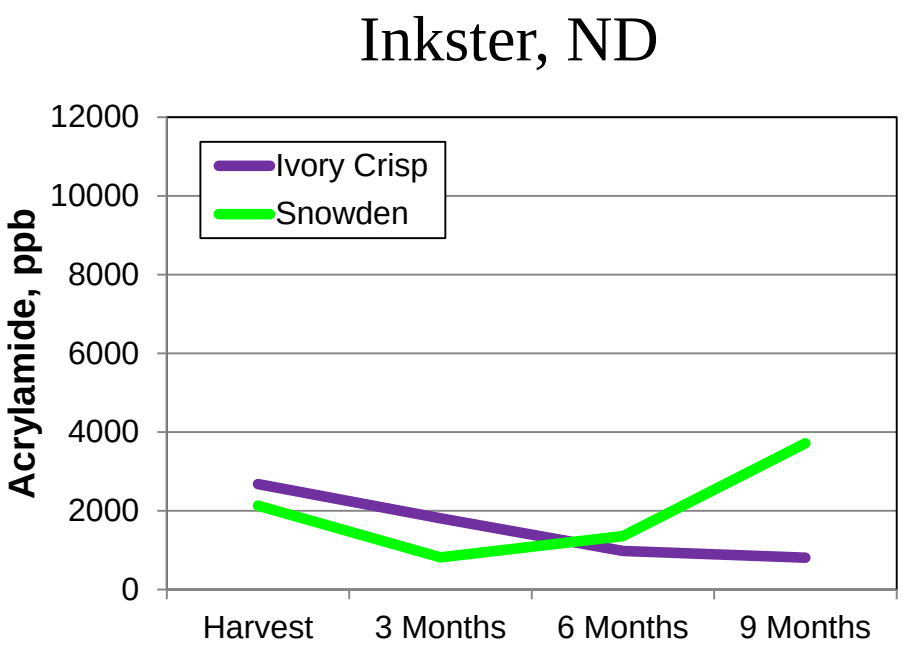
Becker – glucose lower in IC than Sn at 9 months

Inkster – glucose lower in IC than Sn at 3 & 9 months; lower than at Becker

Cultivar by Storage Effects - Acrylamide

- Chipping Cultivars -



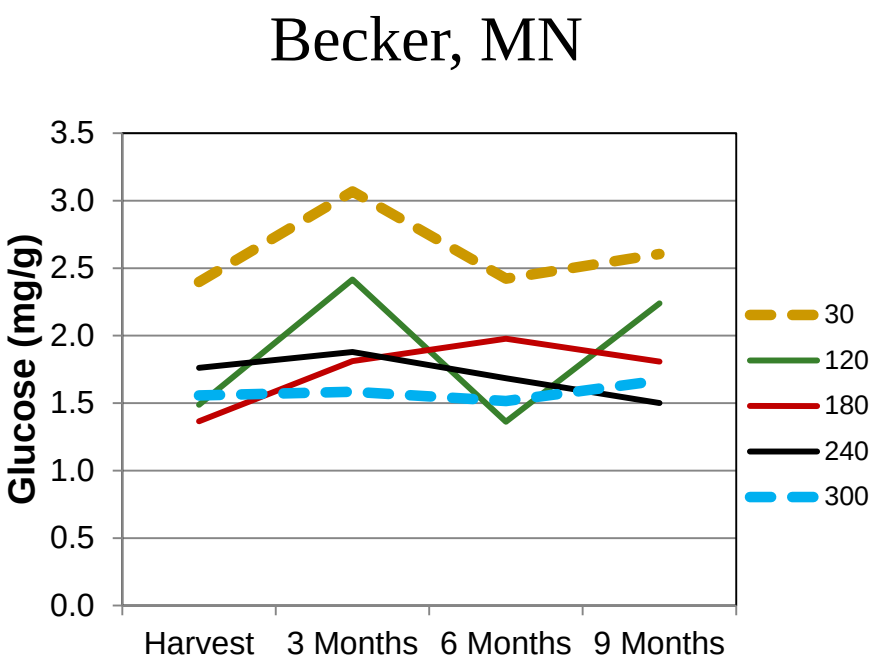


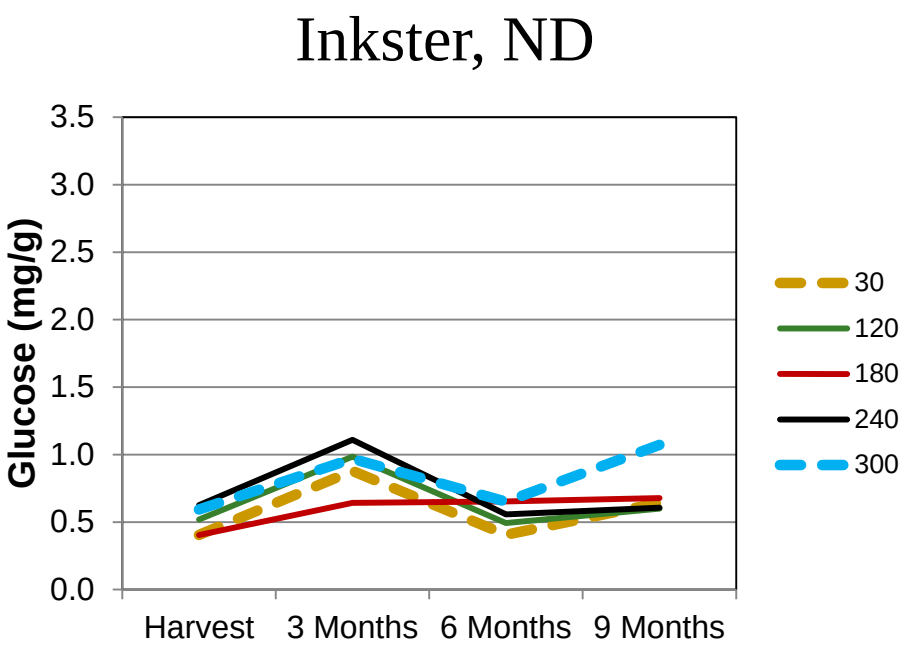
Becker – acrylamide lower in IC than Sn at 9 months; large increase for Sn

Inkster – acrylamide lower than at Becker; decrease with storage for IC; increase for Sn

Nitrogen by Storage effects - Glucose

- Russet Burbank -





Becker – glucose lower with high N; storage effect inconsistent

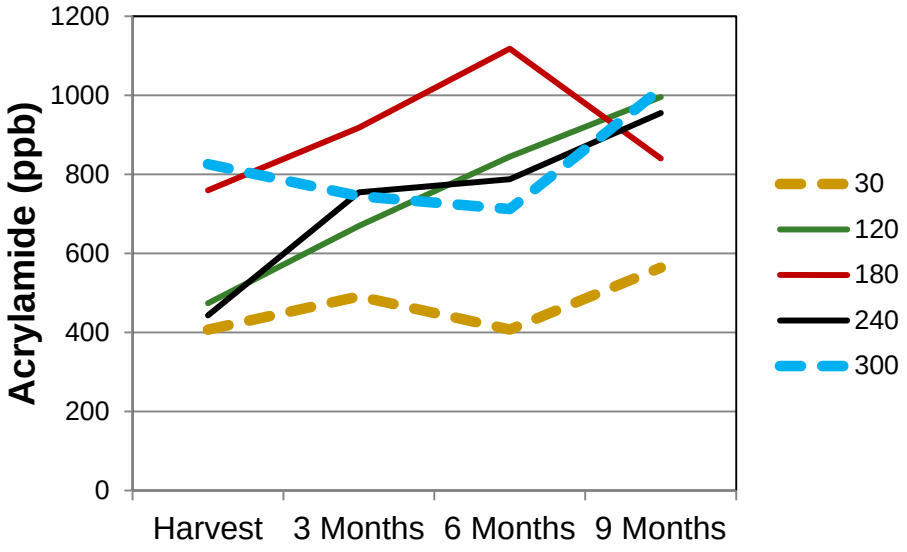
Inkster – glucose slightly lower with low N; generally storage effect inconsistent

Glucose lower at Inkster than at Becker

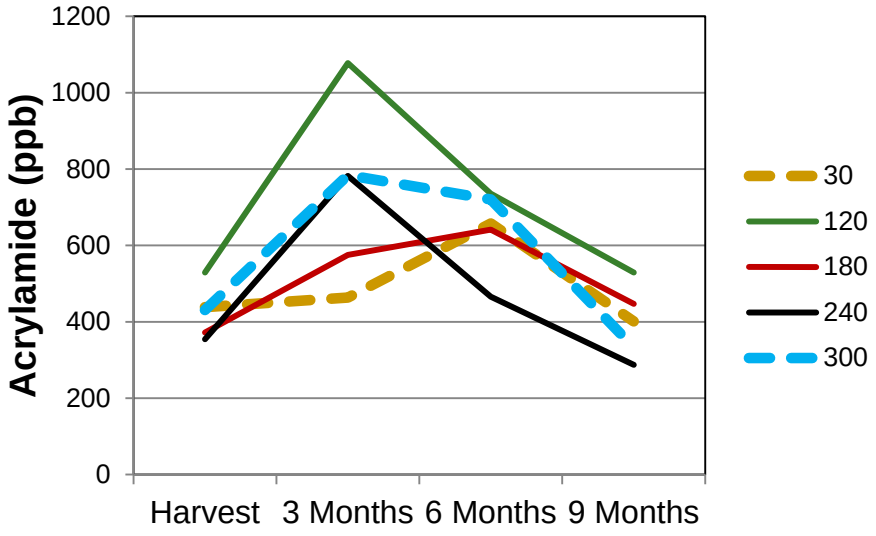
Nitrogen by Storage Effects - Acrylamide

-Russet Burbank -

Becker, MN



Inkster, ND



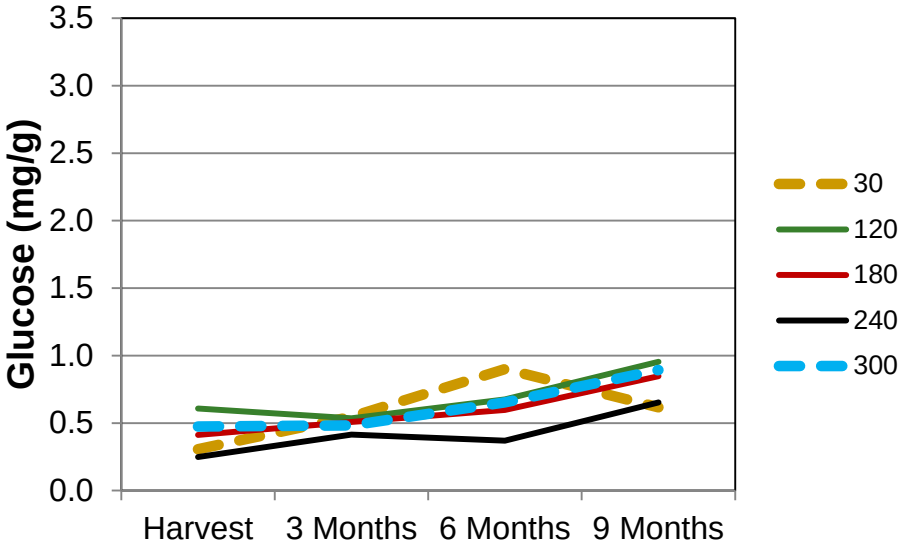
Becker – acrylamide lower with low N (opposite of glucose); increase with storage

Inkster – N effect inconsistent; storage effect inconsistent

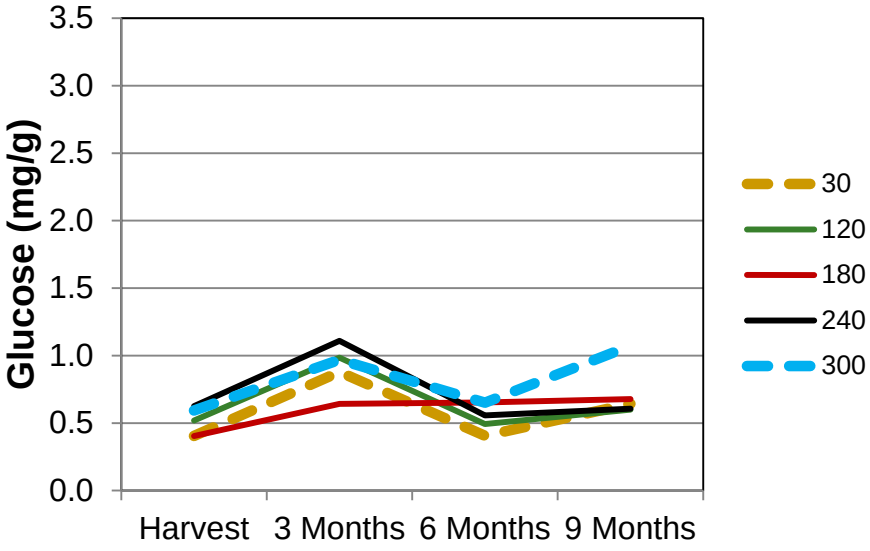
Nitrogen by Storage Effects – Glucose

-Dakota Trailblazer -

Becker, MN



Inkster, ND



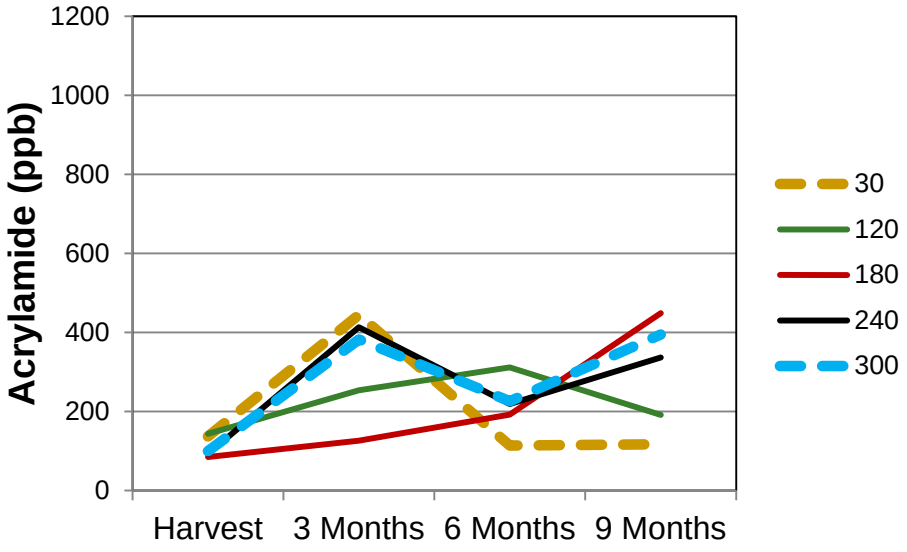
Becker – slight increase in glucose with storage; no N effect

Inkster – erratic storage effect; trend of higher glucose than at Becker

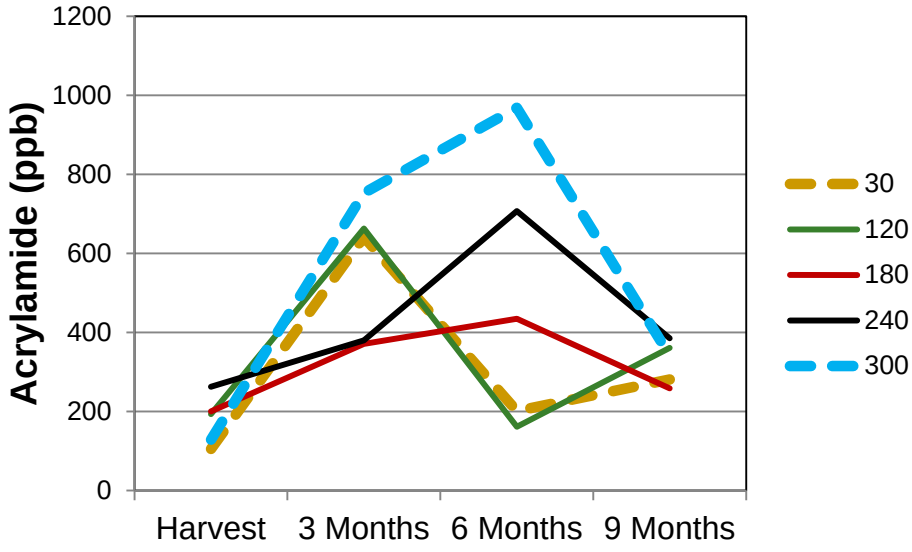
Nitrogen by Storage Effects - Acrylamide

-Dakota Trailblazer -

Becker, MN



Inkster, ND

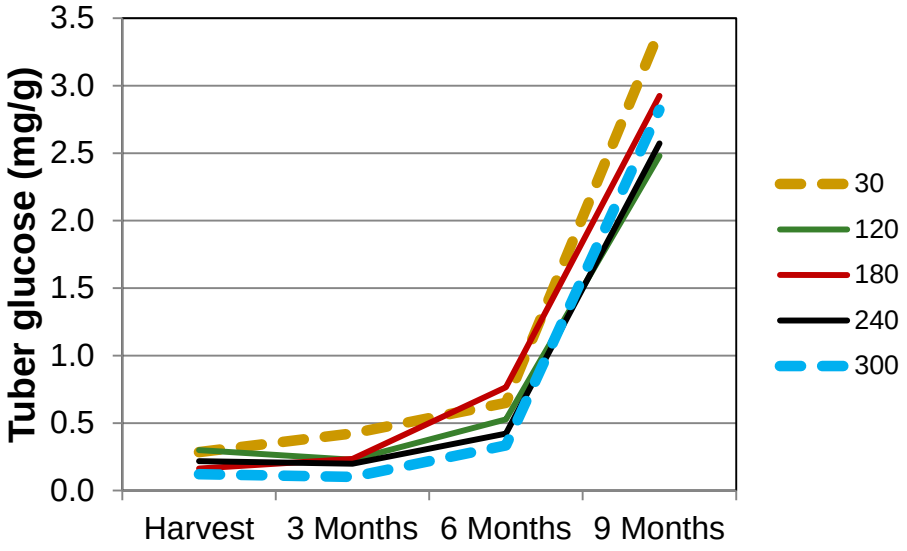


Becker – N effect inconsistent, acrylamide levels lower than at Inkster

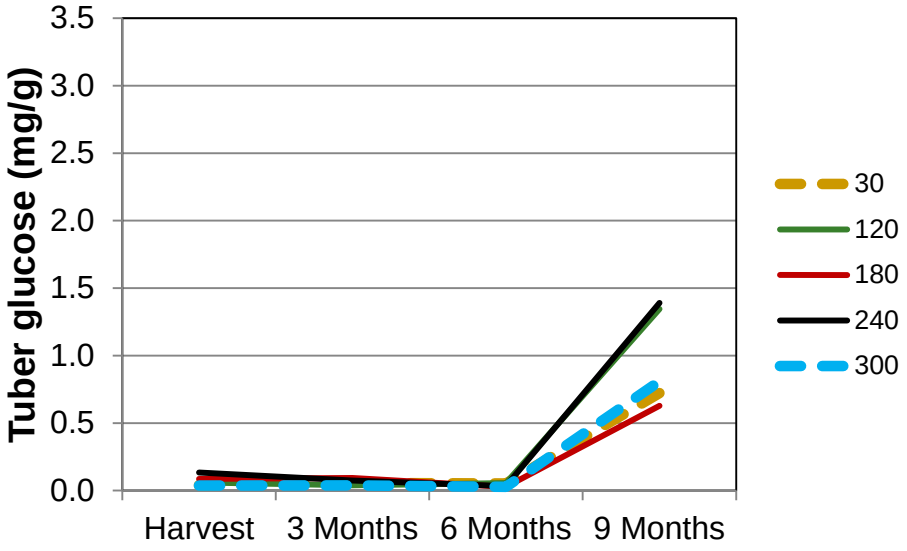
Inkster – erratic N effect; on average lower with low N – esp. at 6 months

Nitrogen by Storage Effects – Glucose - Snowden -

Becker, MN



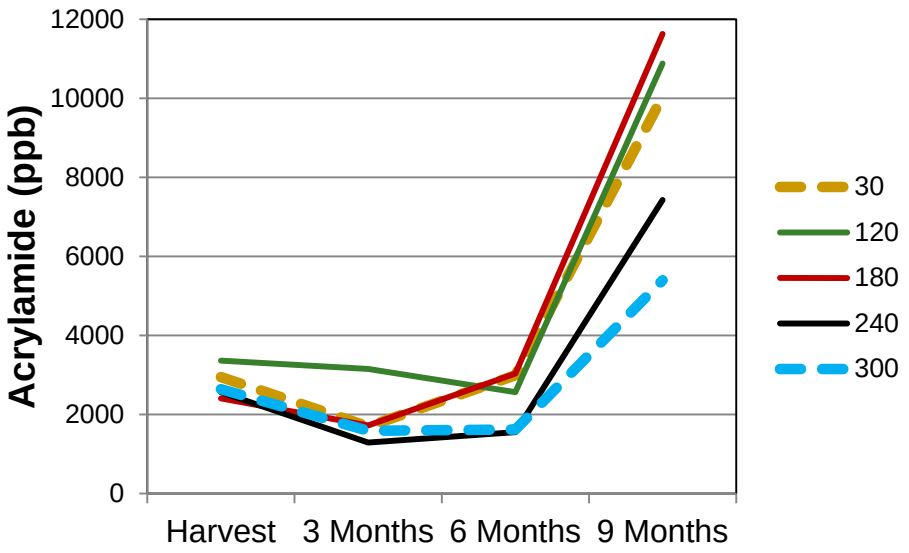
Inkster, ND



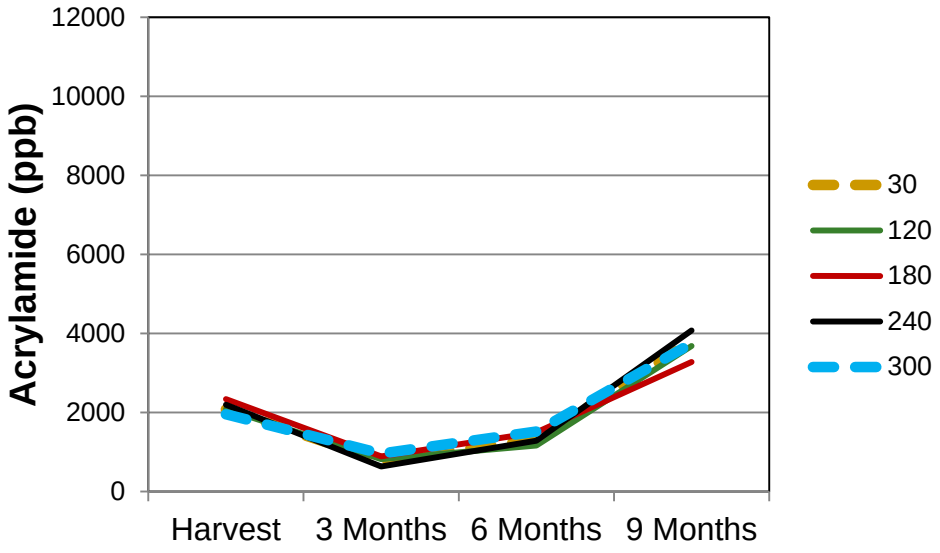
Becker – increasing glucose with longer storage; slightly higher with low N
Inkster – similar trend to Becker, but levels lower and no N effect

Nitrogen by Storage Effects - Acrylamide -Snowden-

Becker, MN



Inkster, ND

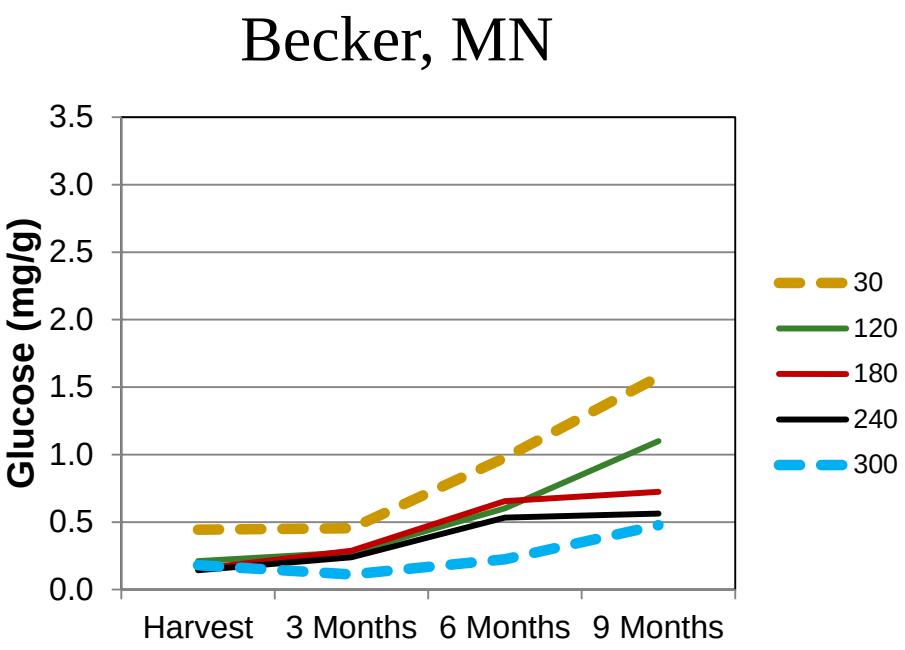


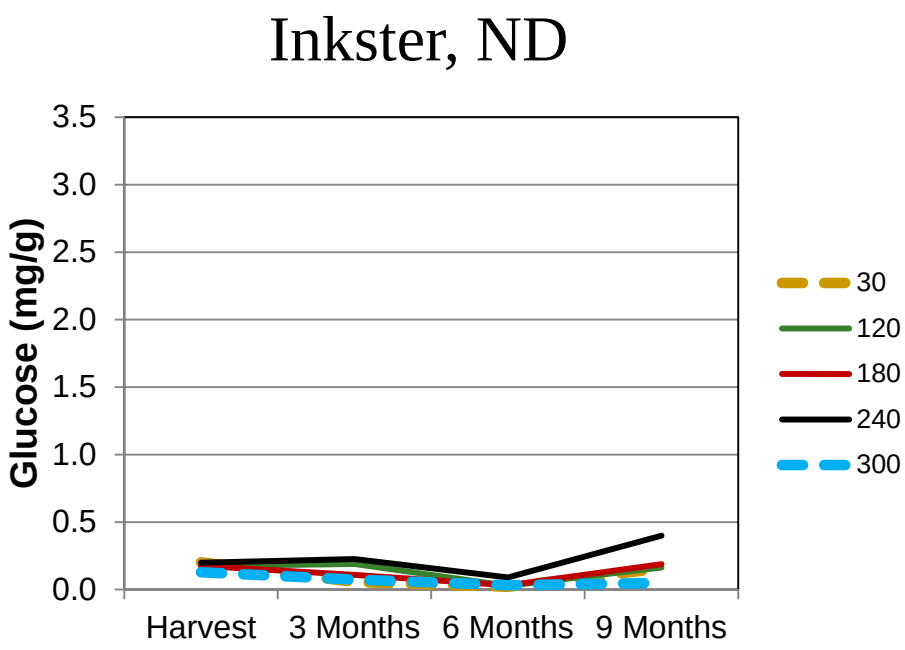
Becker – increasing acrylamide with longer storage and with lower N

Inkster – no N effect and increasing with longer storage

Nitrogen by Storage Effects – Glucose

-Ivory Crisp -



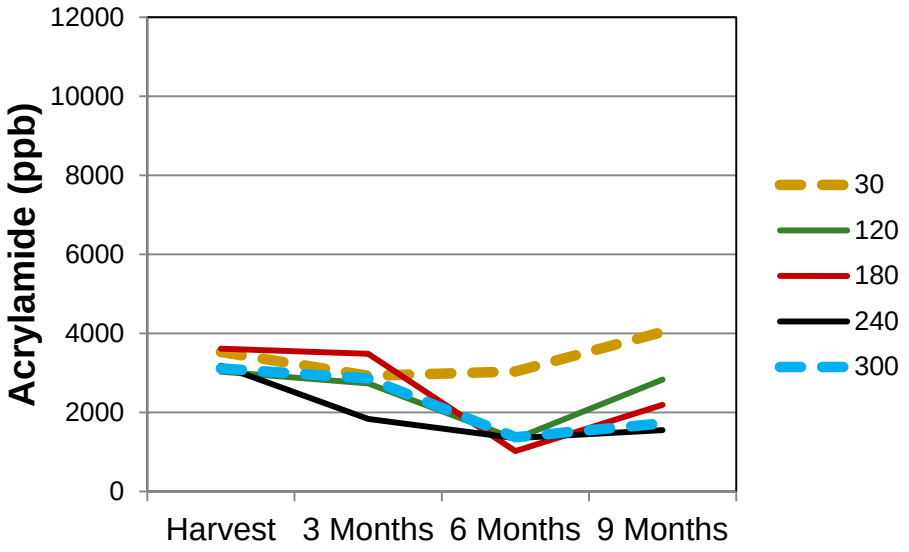


Becker – higher glucose with low N and with longer storage
Inkster – no N effect and lower glucose than at Becker

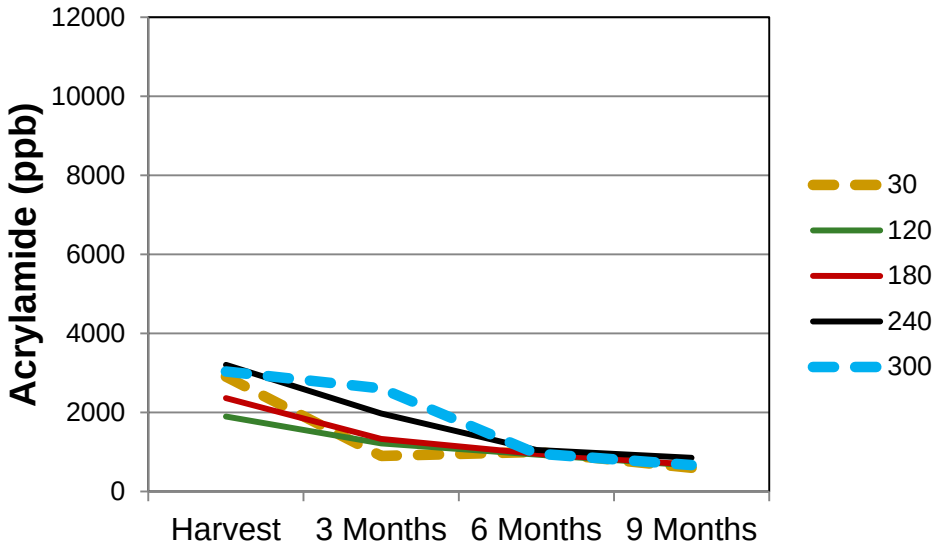
Nitrogen by Storage Effects - Acrylamide

-Ivory Crisp-

Becker, MN



Inkster, ND



Becker – higher acrylamide with low N

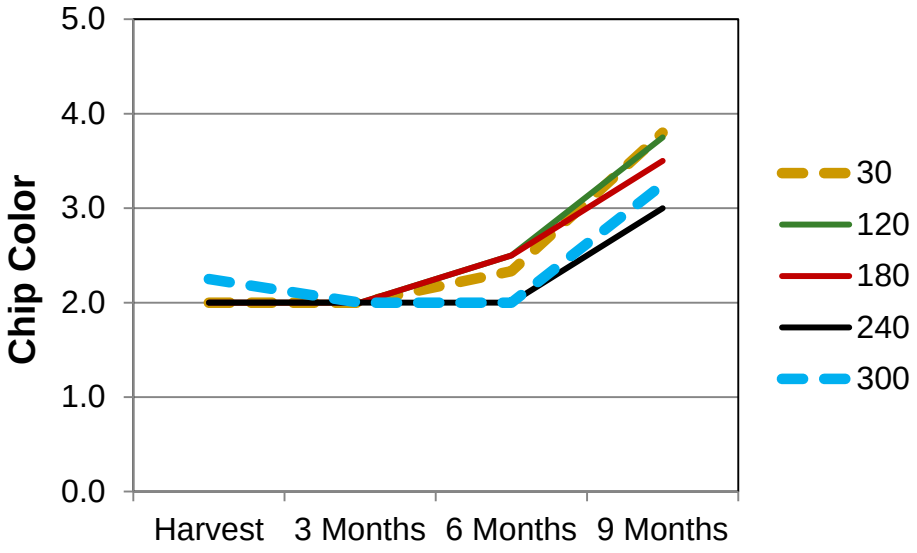
Inkster – no N effect and acrylamide lower than at Becker

Acrylamide tended to decrease with storage – esp. at Inkster

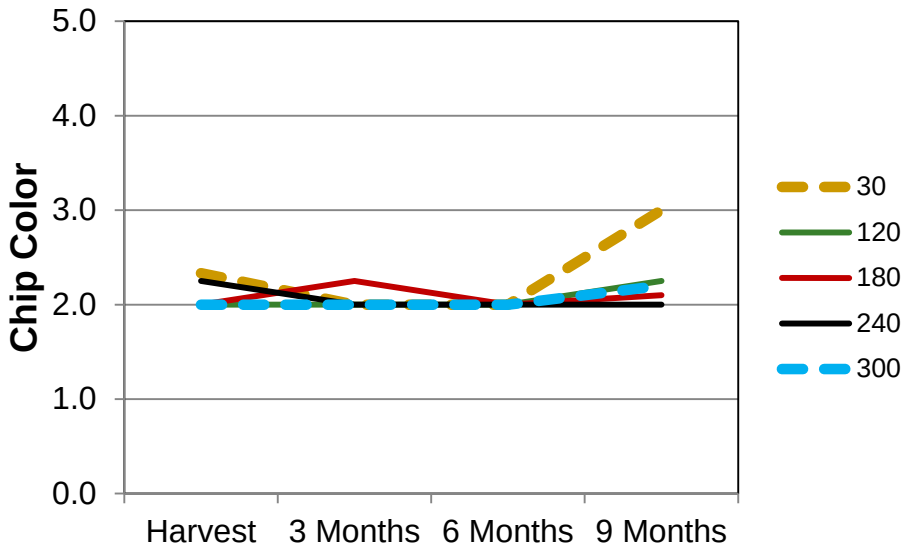
Nitrogen by Storage Effects – Chip Color

Becker, MN

Snowden



Ivory Crisp



Chip color followed the same trend as acrylamide and glucose – darker with storage for Snowden and low N Ivory Crisp

Acrylamide - Summary

- For most cultivars, glucose and acrylamide increased with increasing storage at Becker, but not at Inkster
- Nitrogen rate effect on acrylamide depended on cultivar, location and storage time
  - very difficult to draw a general conclusion for N
- For frying cultivars -
  - Lowest acrylamide in Dakota Trailblazer at Becker
  - Lowest acrylamide with Alpine Russet at Inkster

Acrylamide - Summary

- For chipping cultivars, Ivory Crisp had lower acrylamide than Snowden at both sites, especially at the 9 month storage time
- Glucose did always predict acrylamide
- Cultivar selection has a greater effect on acrylamide than adjusting N rates
- Study was repeated in 2012; Results for sugar and acrylamide contents are in progress

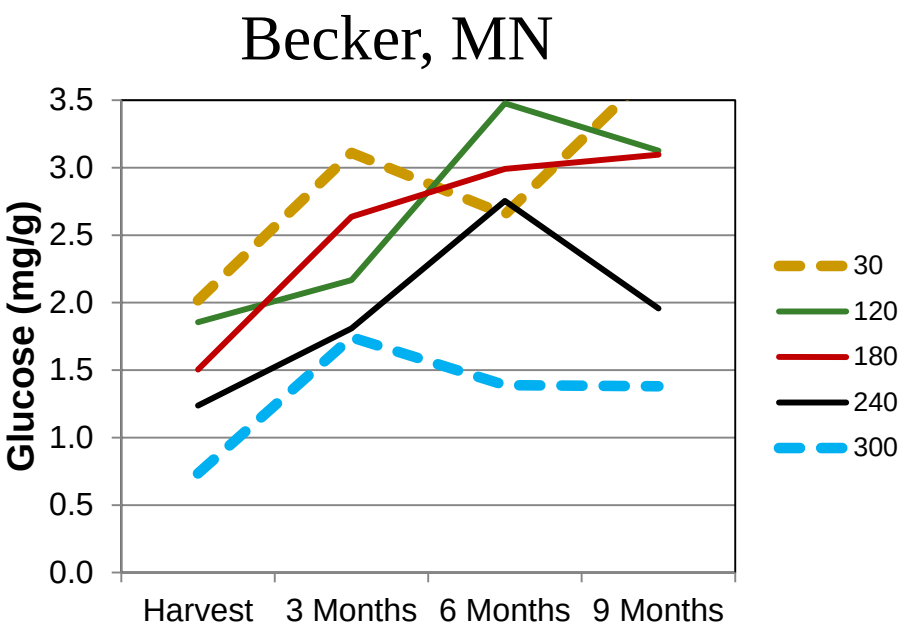
Weather Regimes: 2011vs. 2012

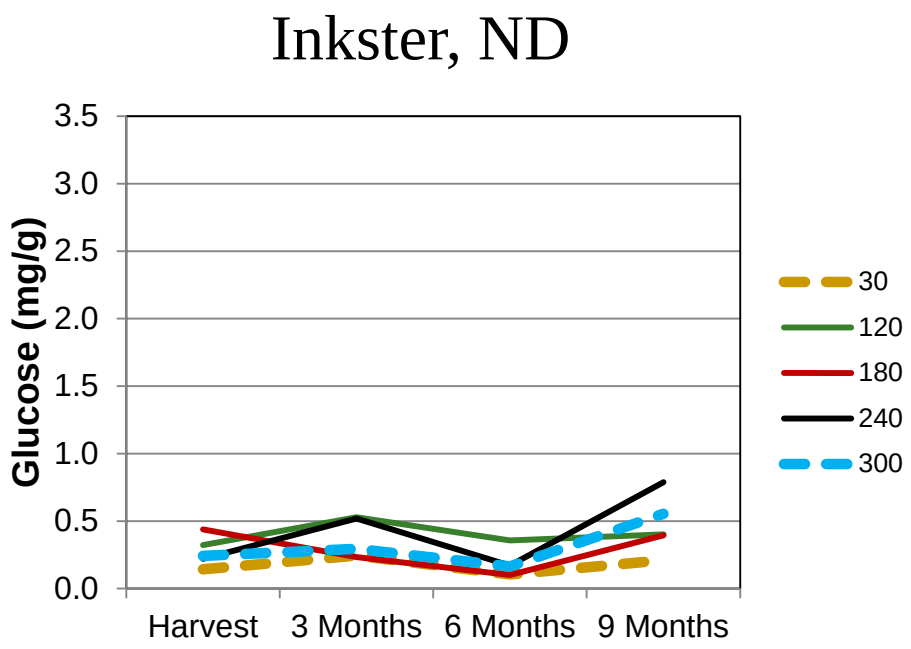
	2011				2012			
	Max	Min	Ave	Diff	Max	Min	Ave	Diff
April	54	33	**44**		58	36	**47**	
May	66	46	**56**		72	51	**61**	
June	77	57	67	**20**	81	58	70	**22**
July	87	65	76	**22**	87	66	77	**21**
Aug	81	59	70	**22**	80	57	69	**23**
Sept	71	47	59	**24***	75	45	60	**30***
	(*Freeze on Sept. 16)				(*Freeze on Sept. 23)			

May-July Rainfall: 18.4” 19.7”

Nitrogen by Storage Effects – Glucose

-Alpine Russet -

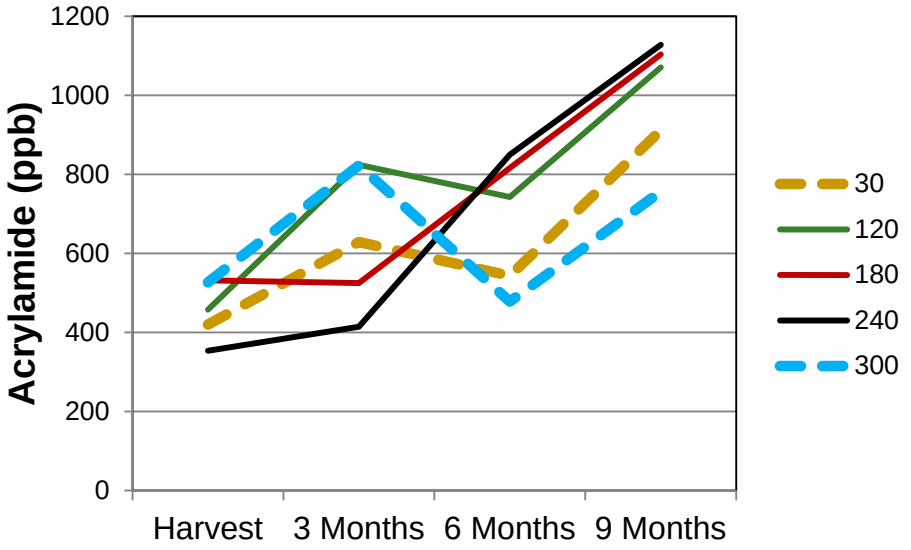




Nitrogen by Storage Effects - Acrylamide

-Alpine Russet-

Becker, MN



Inkster, ND