Quantifying Agricultural Drought:
An Assessment Using Western Canadian Spring Wheat

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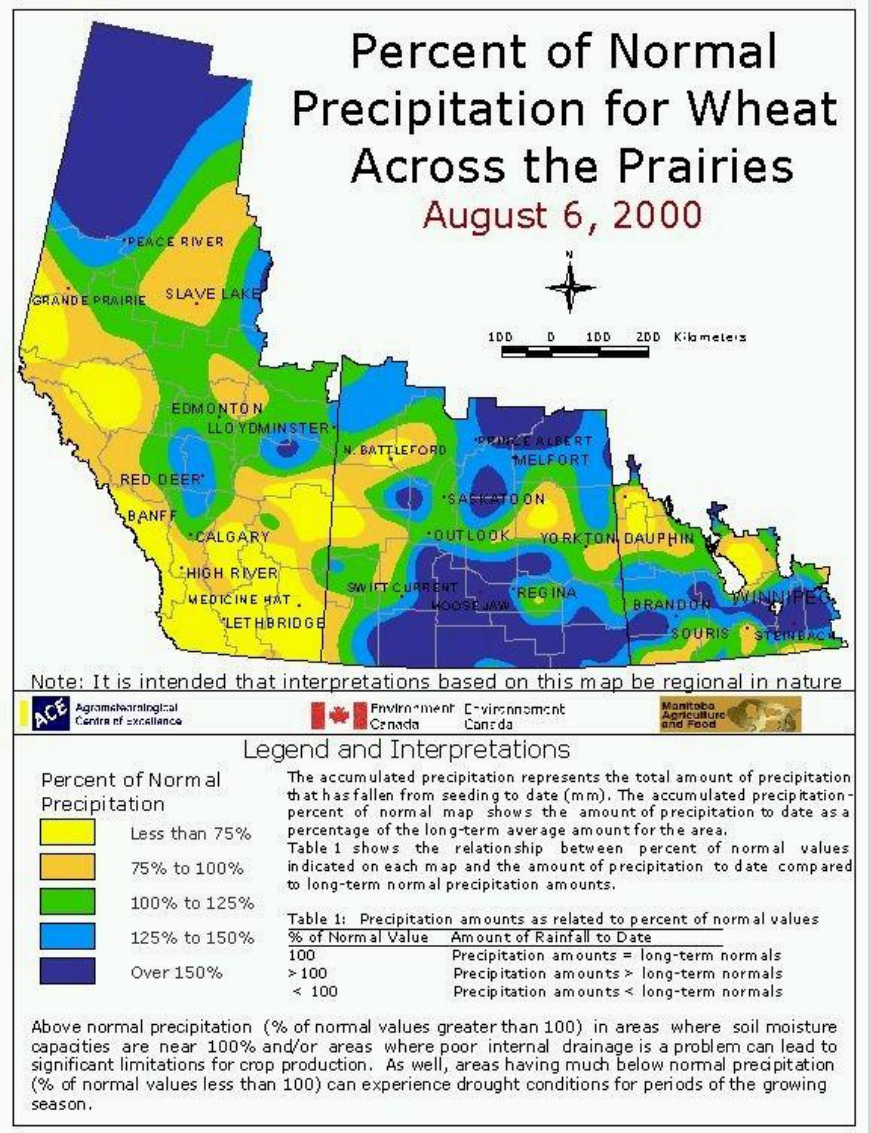
Background

- Precipitation indices alone may not provide the most accurate indications of drought impacts on crops.
- Agricultural drought is a function of both moisture supply and demand.
- Which combination of moisture variables most accurately quantify the impact of drought on spring wheat yield and quality?



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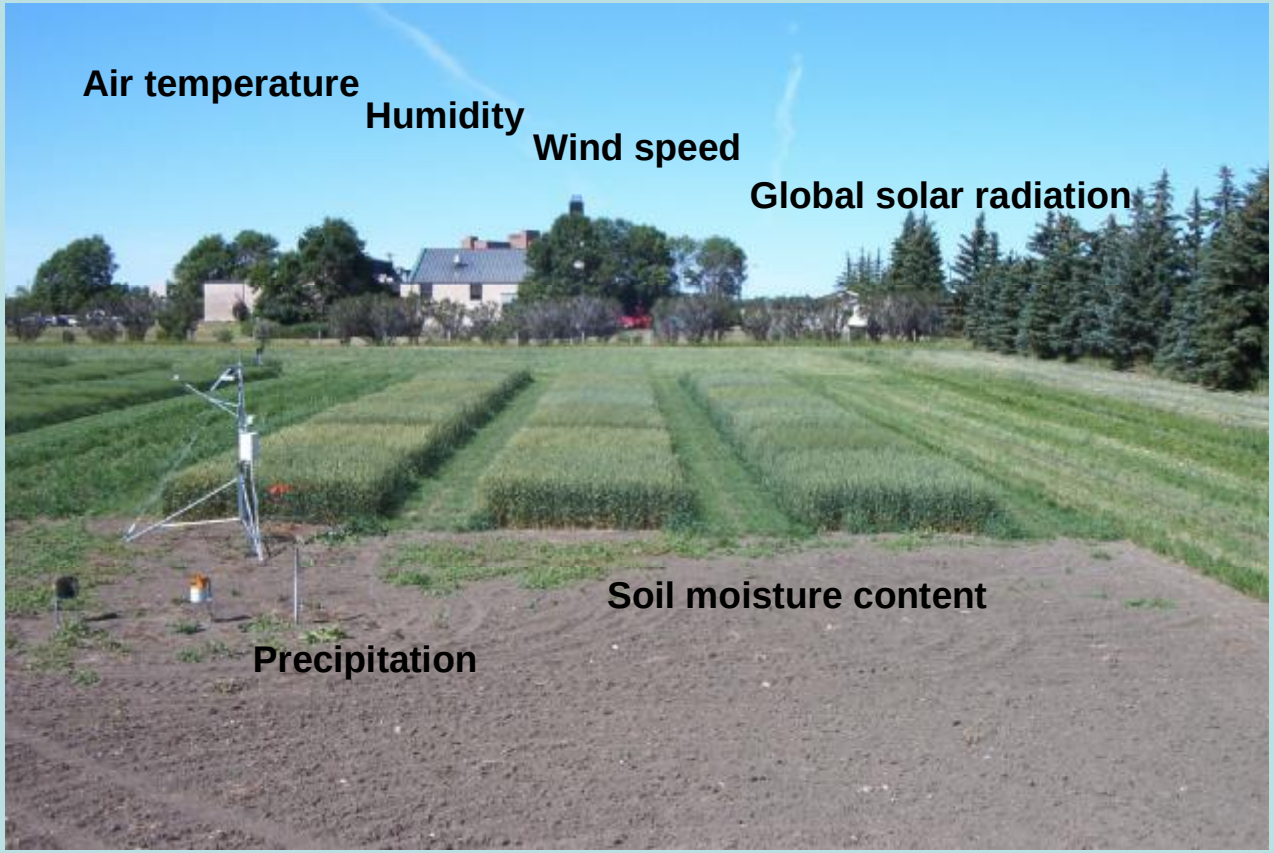
NORTHWEST TERRITORIES
NUNAVUT
Hudson Bay
60°
N
B.C.
ALBERTA
MANITOBA
55°
Growing Seasons
2003, 2004
7 site-years
ONTARIO
Melfort
SASKATCHEWAN
Regina
Swift Current
Winnipeg
Carman
50°
Idaho
115°
Montana
UNITED STATES
105°
North Dakota
95°
0 100 200 mi
0 100 200 km

Field Locations

- Six varieties were sown in a randomized complete block design with three replicates.
- Detailed weather and soil moisture measurements were made at each location.



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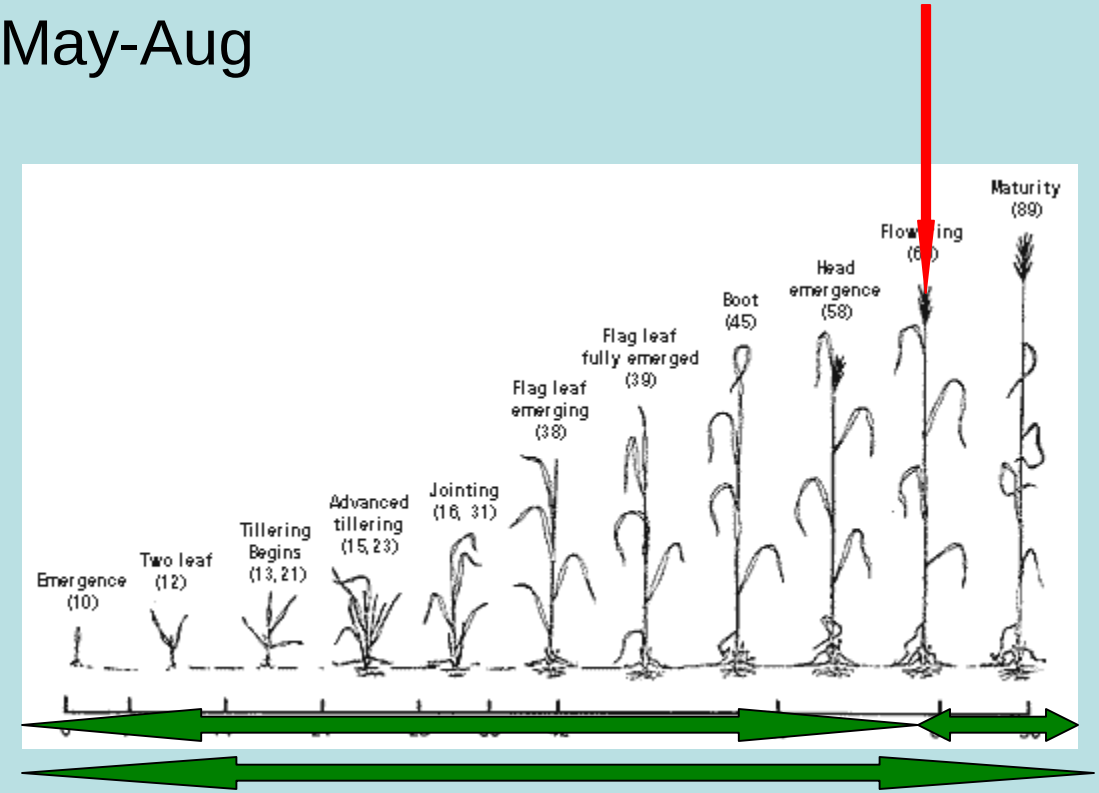
Moisture Indicators Evaluated

- **Prec** – total precipitation (daily precipitation)
- **%Nor** – percent of normal precipitation (precipitation normals)
- **SPI** – Standardized Precipitation Index (long term monthly precipitation)
- **SimETo** – Simple Reference Evapotranspiration (max-min temp, latitude)
- **PMETo** – Penman-Monteith Reference ET (net radiation, humidity, wind)
- **SimETc** – Simple Standard Evapotranspiration (daily crop coefficient)
- **PMETc** – Penman-Monteith Standard ET (daily crop coefficient)
- **SimRes** – Simple Residual Water (soil moisture+precipitation minus ETc)
- **PMRes** – Penman-Monteith Residual Water
- **SimETa** – Simple Actual Evapotranspiration (2-layer soil moisture model)
- **PMETa** – Penman-Monteith Actual Evapotranspiration (as above)
- **BLSMETp, BLSMETa, BLSMRes** – coupled boundary-layer soil moisture model (upper atmosphere wind, humidity and pressure)

Time Periods Evaluated

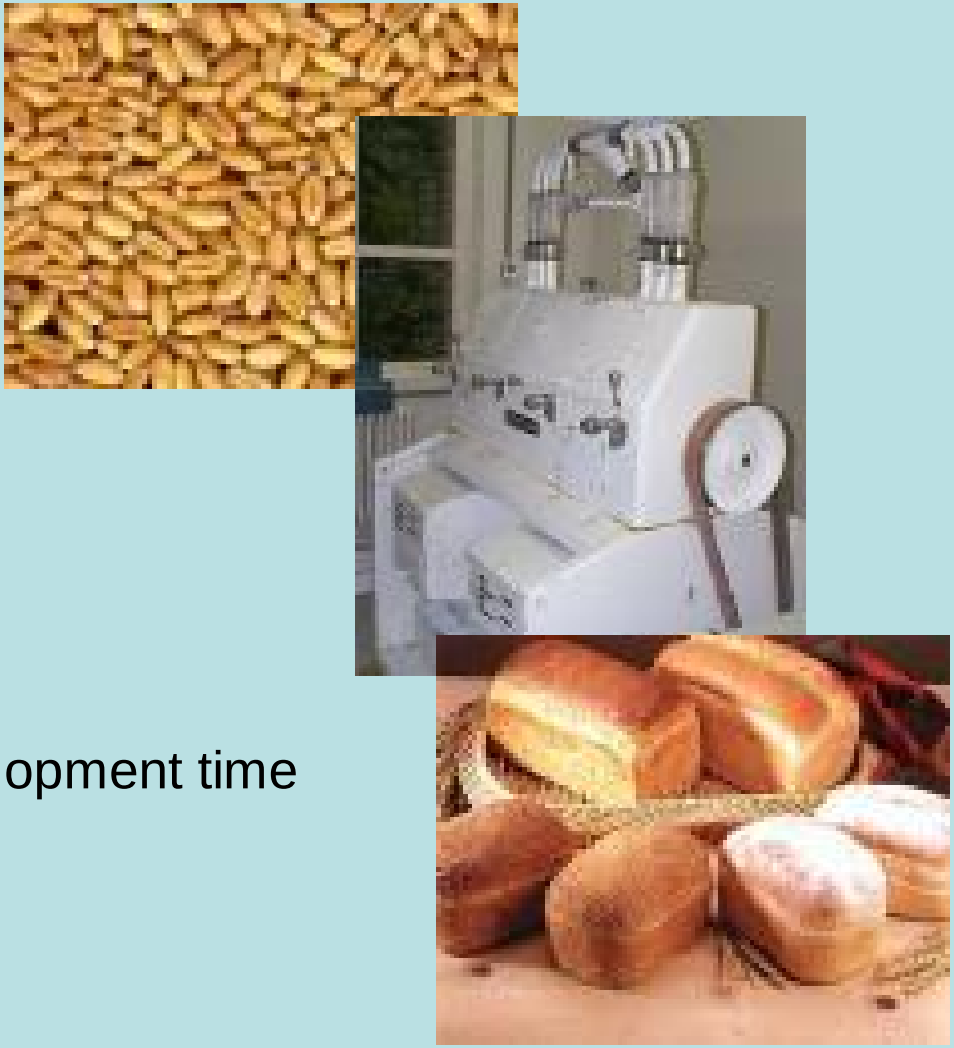
- Monthly
  - May, Jun, Jul, Aug
  - May-Jun, Jun-Jul, Jul-Aug
  - May-Jul, Jun-Aug, May-Aug

- GS - Growing season (Planting-Maturity)
- VP – Vegetative Period (Planting-Anthesis)
- FP – Filling Period (Anthesis-Maturity)



Crop Response Variables

- Grain
  - yield
  - protein content
  - thousand-kernel weight
- Flour
  - extraction rate
  - protein content
  - total pentosan content
- Dough
  - farinograph absorption
  - farinograph dough development time
  - farinograph stability
- Bread
  - loaf volume



Preliminary Results

- There were 341 significant (95%) correlations between the 20 crop response variables and the various moisture indices.
- Barrie Farinograph dough development time was significantly correlated with 40 different moisture indices.
- Barrie flour extraction level was not significantly correlated to any moisture index.

Example:

Flour Pentosan Content

Variety	Moisture Index	r
Superb	**Aug Prec**	-0.76 *
	Aug %Nor	-0.81 *
	FP %Nor	-0.77 *
	Aug SPI	-0.82 *
	May BasETc	0.91 **
	May-Jun BLSMETp	0.95 **

* Significant at 95% ** Significant at 99%

Variety	Moisture Index	r
Barrie	**May-Jun BasETc**	0.76 *
	May BasETa	0.76 *
	May PMETa	0.76 *
	Jun BLSMETp	0.79 *
	Jun BLSMETa	0.91 **

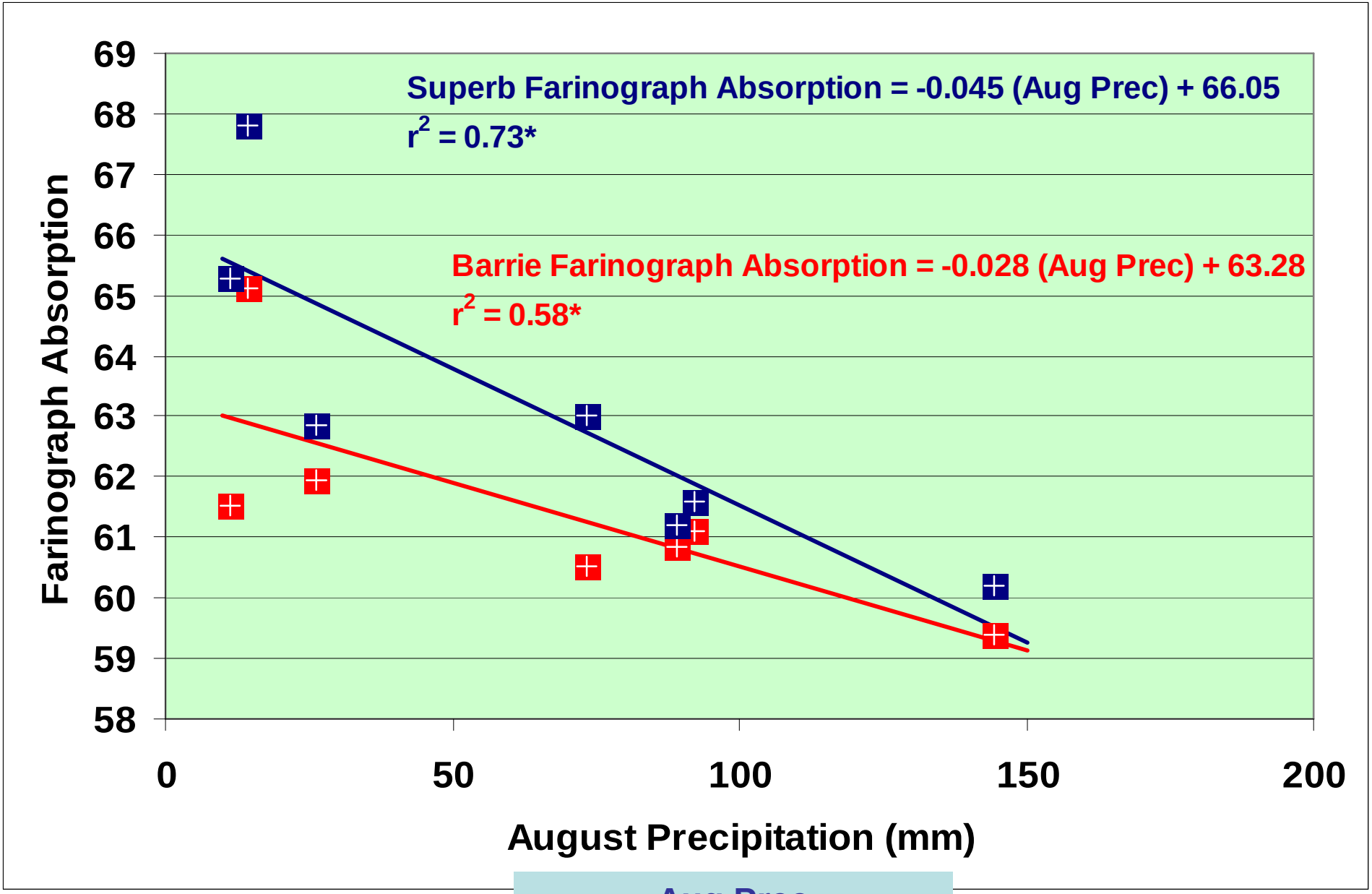
* Significant at 95% ** Significant at 99%

Preliminary Results

- Least complex significantly correlated moisture index

	-------- Barrie -------		------ Superb ------	
Crop Variable	Moisture Index	r	Moisture Index	r
Yield	**Jul PMETo**	-0.80 *	**Jul SimETo**	-0.80 *
Protein	**GS SimETo**	0.90 **	**GS SimETo**	0.90 **
1000 ker wt	**May BLSMETa**	0.78 *	**FP SimETc**	0.76 *
Flour extr		ns	**May SimETa**	0.79 *
Flour prot	**GS SimETo**	0.86 *	**GS SimETo**	0.91 **
Flour pent	**May-Jun SimETc**	0.76 *	**Aug Prec**	-0.76 *
Far absorp	**Aug Prec**	0.76 *	**Aug Prec**	0.85 *
Far DDT	**VP SimETo**	0.79 *	**GS SimETo**	0.79 *
Far stability	**May-Jun Prec**	-0.76 *	**Jul SimETo**	0.84 *
Loaf Vol	**GS SimETo**	0.93 **	**GS SimETo**	0.92 **

* Significant at 95% ** Significant at 99%



Aug Prec

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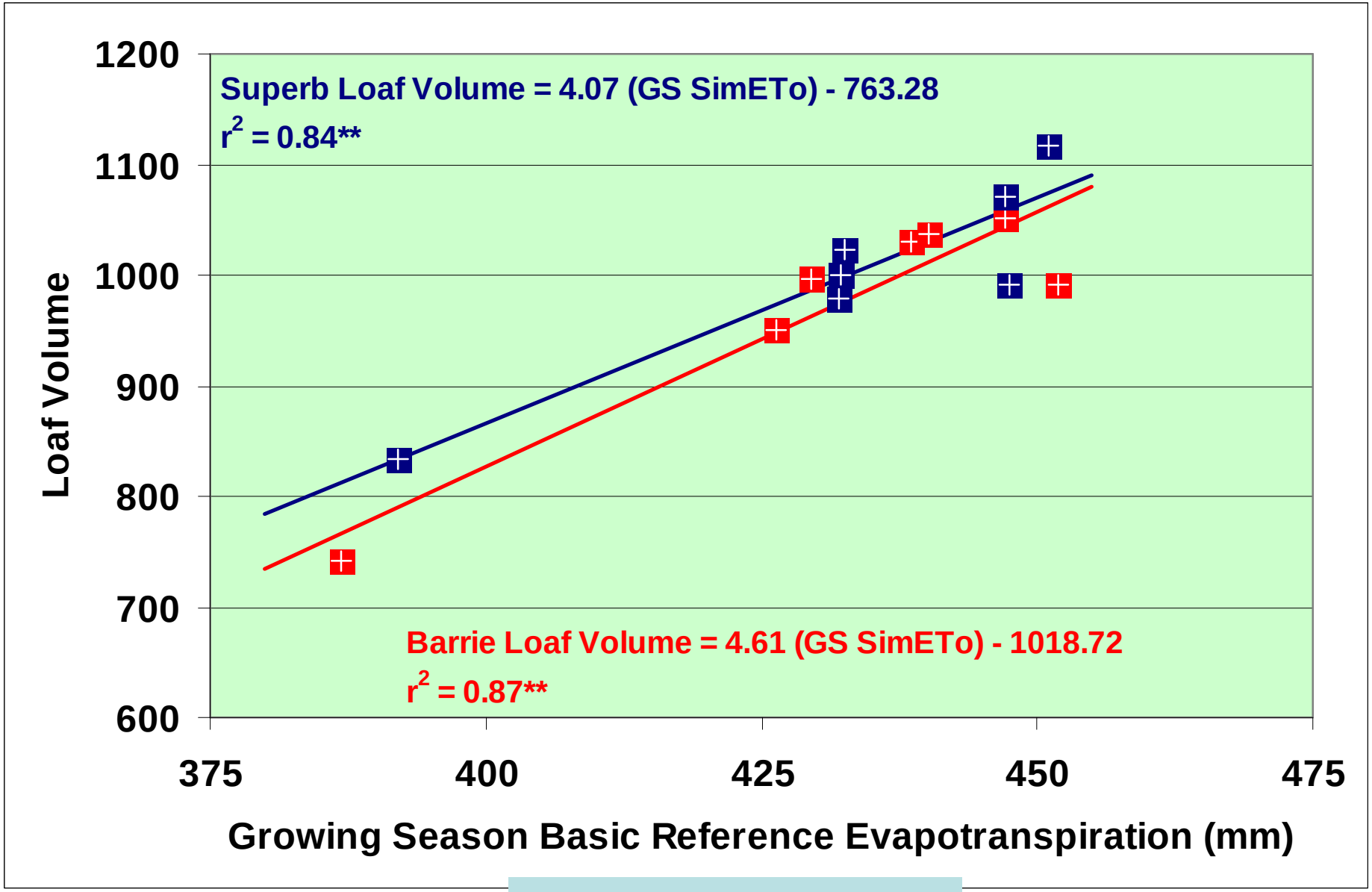

GS SimETo

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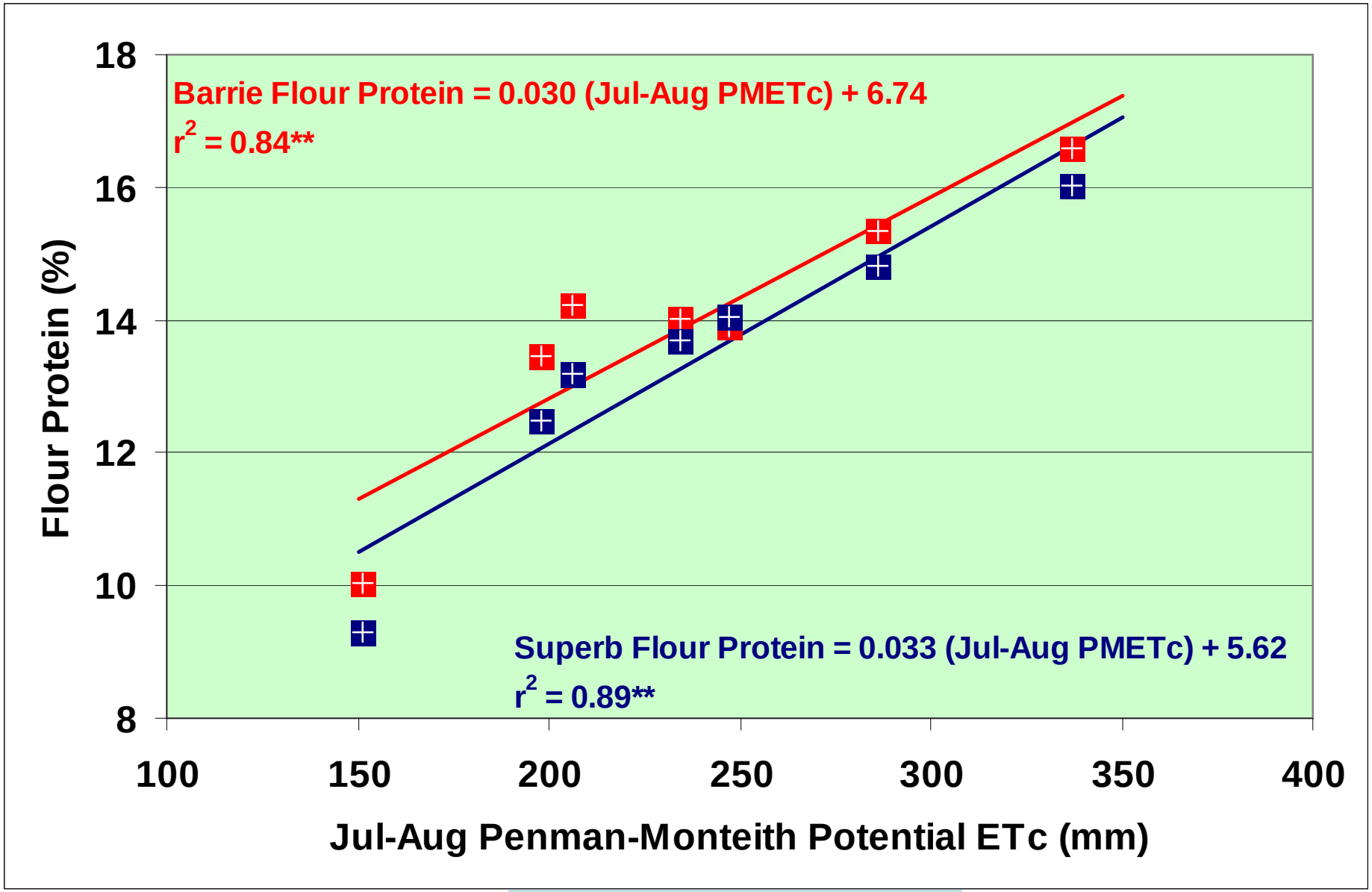
Preliminary Results

- Moisture index with the highest absolute correlation coeff.

	Barrie		Superb	
Crop Variable	Moisture Index	r	Moisture Index	r
Yield	**FP BLSMETa**	0.87 *	**Jul-Aug BLSMETp**	-0.85 *
Protein	**GS SimETo**	0.90 **	**Jul-Aug PMETc**	0.94 **
1000 ker wt	**May BLSMETa**	0.78 *	**FP SimETc**	0.76 *
Flour extr	**May-Jun BLSMRes**	-0.69 ns	**May BasETa**	0.79 *
Flour prot	**Jul-Aug PMETp**	0.92 **	**Jul-Aug PMETc**	0.94 **
Flour pent	**Jun BLSMETa**	0.91 **	**May-Jun BLSMETp**	0.94 **
Far absorp	**May PMETa**	0.90 **	**May-Jun PMETc**	0.88 **
Far DDT	**VP PMETc**	0.95 **	**VP SimETo**	0.90 **
Far stability	**Jul SimETc**	0.93 **	**VP SimETc**	0.92 **
Loaf Vol	**GS SimETo**	0.93 **	**Jul-Aug PMETc**	0.94 **

* Significant at 95% ** Significant at 99%



Jul-Aug PMETc

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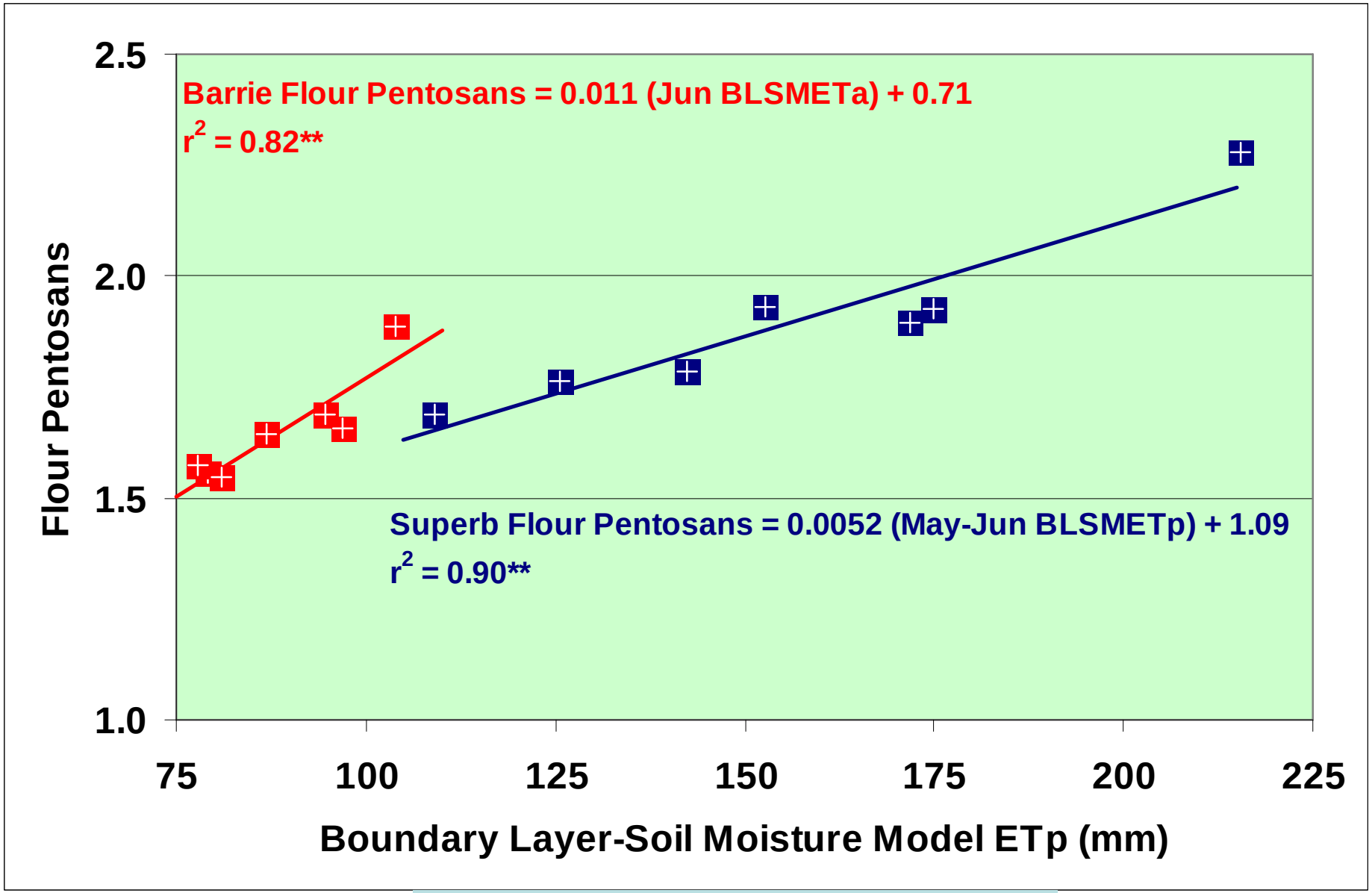

Jun BLSMETa May-Jun BLSMETp

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Preliminary Observations

- Precipitation and precipitation-based moisture indices were not significantly correlated to spring wheat yield nor most wheat quality parameters.
- There was more frequently a significant correlation between water demand variables and wheat response.

Preliminary Observations

- Simple reference evapotranspiration was significantly correlated to several important wheat quality measures including grain protein, flour protein and loaf volume.
- More data points are needed to ensure the relationships are real.

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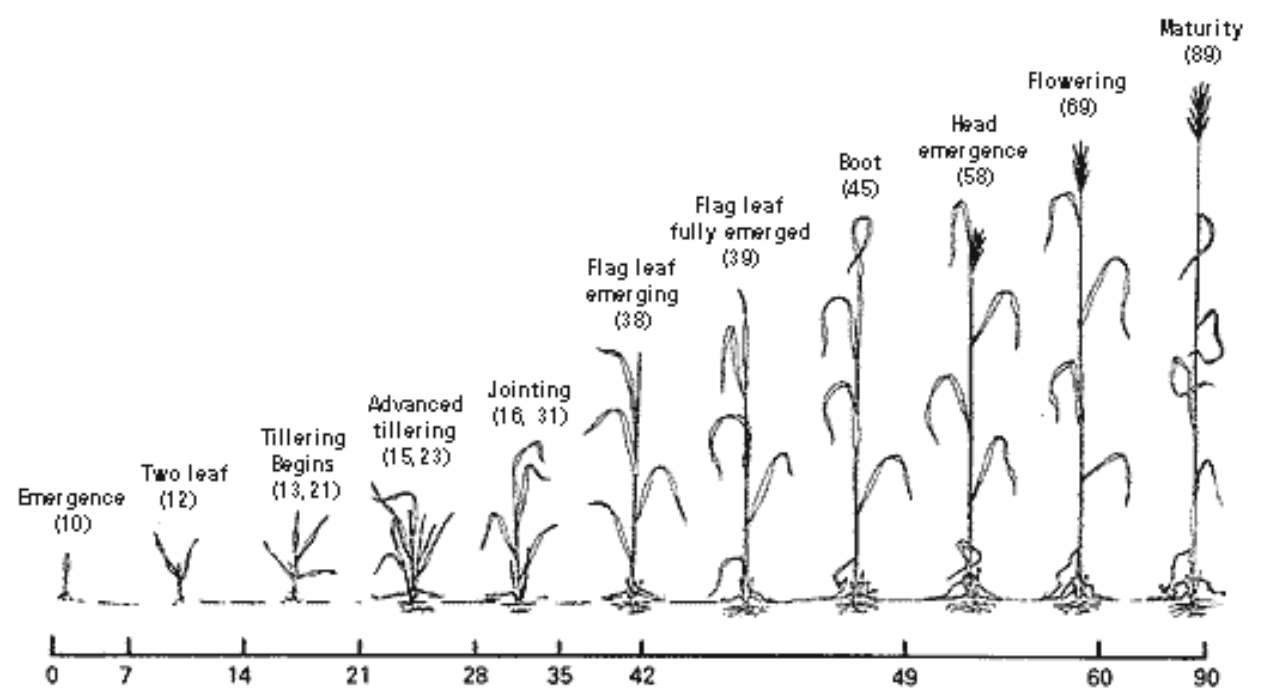
Preliminary Observations

- More sophisticated moisture indices requiring additional weather and soil data frequently had higher correlation coefficients to many crop response variables.

- Is it worthwhile collecting the additional data for these indices???

Preliminary Observations

- Phenological growth stage rather than monthly moisture indices in some cases had higher correlation coefficients to crop response variables and may be a means to improve crop outcome predictions.



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