Environmental and Agronomic Factors Affecting the Nutritional Quality of Corn Silage

Virginia Tech Nutritional Management "Cow College"

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Pre-harvest Factors
Outline

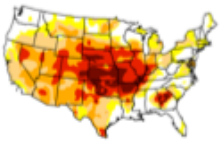
- Abiotic stresses
- Planting density
- Row spacing

Pre-harvest Factors
Abiotic Stresses

2012

Pre-harvest Factors
Abiotic Stresses

- Spring and summer drought of 2012 will be remembered as one of the ***"worst agricultural calamities"*** in the US (USDA, 2013)
- Drought of 2012 reduced the national corn grain and silage yields by 16.2 and 16.3%, respectively (USDA, 2013)



US Drought Monitor (08/21/12)

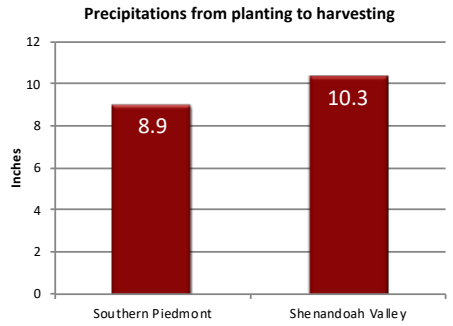
Pre-harvest Factors
Abiotic Stresses

Pre-harvest Factors
Corn Silage Hybrid Tests – 2012

Hybrid	Southern Piedmont	Shenandoah Valley
	ton DM/acre	ton DM/acre
A	2.3	6.1
B	2.1	8.0
C	2.0	7.7
D	1.9	5.9
E	2.2	5.2
F	2.0	4.2
G	1.9	5.2
H	2.0	3.0
Average	**2.0**	**5.6**

Behl et al. (2012) *Virginia Cooperative Extension*

Pre-harvest Factors
Corn Silage Hybrid Tests – 2012



Pre-harvest Factors
Abiotic Stresses

- Nutritional Quality
  - 28% DM
  - 11.6% CP
  - 60% NDF
  - pH = 3.96

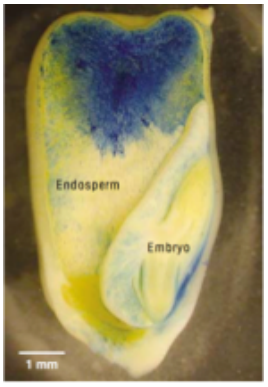


Photo from Walbot and Evans (2003) *Nature Reviews*

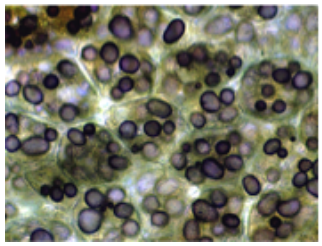
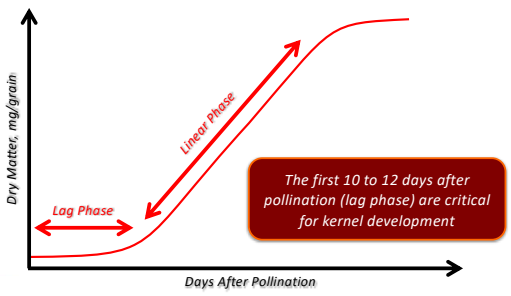


Photo from http://science.marshall.edu/murraye/alpha_amylase.htm

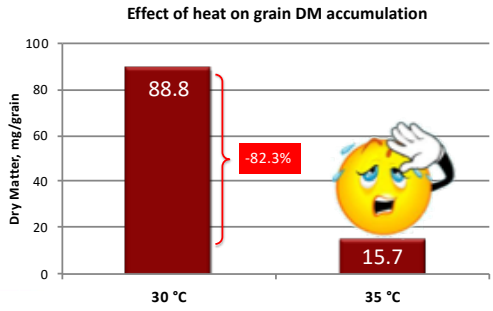
Pre-harvest Factors
Kernel Development



Pre-harvest Factors
Kernel Development

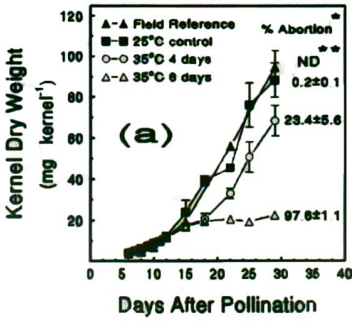
- The first 10-12 days after pollination (lag phase) are critical for kernel development
  - The capacity of the endosperm to accumulate dry matter is established
    - More endosperm cells imply more amyloplasts
    - More amyloplasts imply more starch

Pre-harvest Factors
Kernel Development

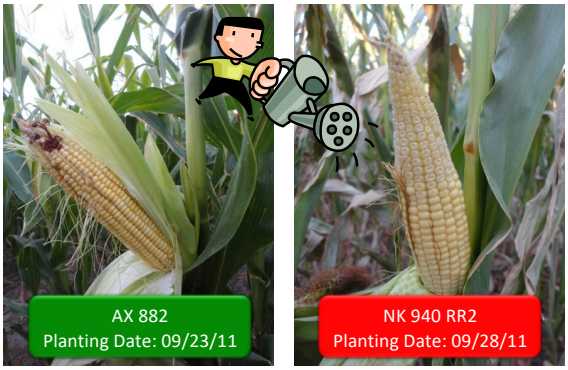


Hanft and Jones (1986) *Plant Physiology*

Pre-harvest Factors
Kernel Development

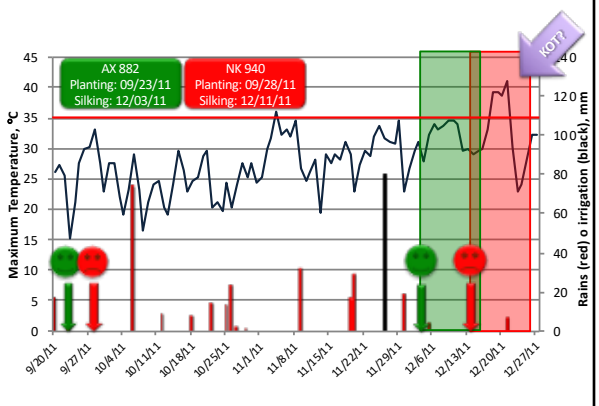


Cheikh and Jones (1994) *Plant Physiology*



Pre-harvest Factors
Growing-degree Days (GDD)

Date	T Max	T Min	Formula	GDD	Cum GDD
May 1	85	62	(85+62)/2 – 50	24	24
May 2	89	64	(86+64)/2 – 50	25	49
May 3	85	61	(85+61)/2 – 50	23	72
May 4	87	65	(86+65)/2 – 50	26	98
May 5	79	62	(79+62)/2 – 50	21	119
⋮	⋮	⋮	⋮	⋮	⋮
Jul 15	95	68	(86+68)/2 – 50	27	1338
Jul 16	82	55	(82+55)/2 – 50	19	1357
Jul 17	89	56	(86+56)/2 – 50	21	1378
Jul 18	98	64	(86+64)/2 – 50	25	1403
Jul 19	107	71	(86+71)/2 – 50	29	1432
Jul 20	103	67	(86+67)/2 – 50	27	1459



Dry matter concentration of whole-plant corn for silage

Hybrid	Southern Piedmont		Shenandoah Valley	
	2011	2012	2011	2012
Rains	19.7 inches	9.0 inches	11.0 inches	10.3 inches
A	39.6	28.2	32.2	37.4
B	34.8	26.9	33.5	34.5
C	33.1	23.8	30.2	34.2
D	38.7	24.9	31.4	28.2
E	34.2	21.1	30.6	28.1
F	40.5	27.5	36.1	48.8
G	38.2	27.4	35.3	39.7
H	36.8	22.5	31.1	32.4
Average	37.0	25.3	32.6	35.4

Data from Behl et al. (2011) and Behl et al. (2012) *Virginia Cooperative Extension*

Neutral detergent fiber (NDF) concentration of whole-plant corn for silage

Hybrid	Southern Piedmont		Shenandoah Valley	
	2011	2012	2011	2012
Rains	19.7 inches	9.0 inches	11.0 inches	10.3 inches
A	51.2	58.4	52.8	42.3
B	49.9	55.7	50.5	44.9
C	52.5	55.4	54.7	41.8
D	47.6	58.8	55.5	42.6
E	50.1	55.6	54.5	45.3
F	57.7	55.9	51.4	40.3
G	51.4	57.6	50.6	42.4
H	51.2	55.5	52.1	44.5
Average	51.5	56.6	52.8	43.0

Data from Behl et al. (2011) and Behl et al. (2012) *Virginia Cooperative Extension*

Pre-harvest Factors
Southern Piedmont 2011

Ferreira et al. (2015) *Maydica*

Pre-harvest Factors
Shenandoah Valley 2011

Ferreira et al. (2015) *Maydica*

Pre-harvest Factors
Southern Piedmont 2012

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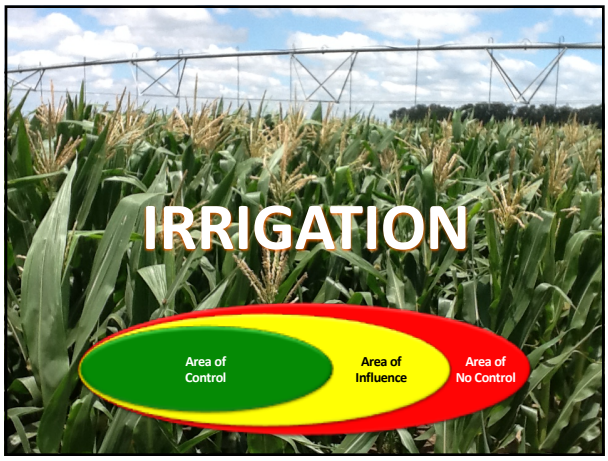
Pre-harvest Factors
Southern Piedmont 2011

Ferreira et al. (2015) *Maydica*



Pre-harvest Factors
Corn Silage Hybrid Tests – Georgia 2012

	Blairsville	Calhoun	Griffin	Tifton
Planting date	Apr 18	Apr 11	Apr 2	Mar 28
Harvesting date	Aug 31	Aug 23	Aug 17	Jul 26
Growing period, days	130	135	138	121
Rainfalls , mm	429	445	388	420
Supplemental irrigation	No	Yes	Yes	Yes
Dry matter yield, ton DM/ac	11.8	10.9	10.3	15.0
Grain component, %	47.5	35.9	50.0	49.3

Data from Coy et al. (2011) *University of Georgia*

Pre-harvest Factors
Blairsville – 47.5% grain

Ferreira et al. (2015) *Maydica*

Pre-harvest Factors
Calhoun – 35.9% grain

Ferreira et al. (2015) *Maydica*

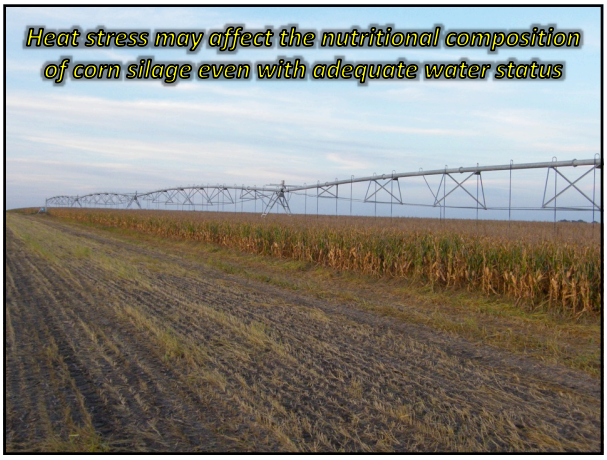
Pre-harvest Factors
Griffin – 50.0% grain

Ferreira et al. (2015) *Maydica*

Pre-harvest Factors
Tifton – 49.3% grain

Ferreira et al. (2015) *Maydica*

In certain regions, dairy farmers should be concerned for high temperatures as much as for drought!



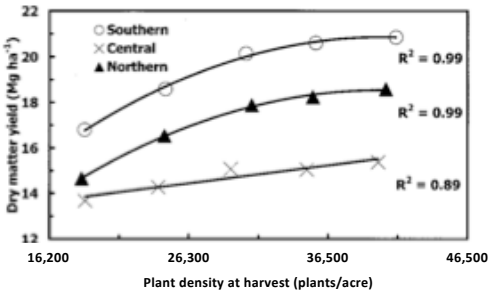
Corn Planting Density
On-farm Study – Argentina

Effect of plant density on yield and composition of whole-plant corn

	Plant Density, plants/acre				
	24,300	28,340	32,400	36,450	P <
Plant Weight, g DM/plant	270.5	263.7	282.8	262.1	0.57
DM Yield, ton DM/acre	7.1	7.8	9.2	10.1	0.01
Neutral Detergent Fiber, %	48.4	47.9	49.2	49.3	0.67
Starch, %	25.1	25.3	23.0	24.5	0.24

Ferreira et al. (2014) *Journal of Dairy Science*

Corn Planting Density
University of Wisconsin



Cusicanqui and Lauer (1999) *Agronomy Journal*

Corn Planting Density
Is There a Target?

Corn Planting Density
On-farm Studies – 7 fields from VA

Table 2. Effect of planting density on DM yield and plant structure of corn

	Planting density[1]					P < [2]		
Item	22K	28K	34K	40K	SEM	Trt	L	Q
DM, %	32.1	31.7	31.5	31.4	0.28	0.29	0.07	0.59
Plant dry weight, g/plant	376	334	284	253	7.4	0.01	0.01	0.46
DM yield, Mg/ha	8.0	8.7	9.4	10.5	0.5	0.01	0.01	0.41
Kernel lines per ear, count	17.1	16.5	16.0	16.3	0.26	0.03	0.02	0.09
Kernels per line, count	42.2	38.9	35.6	33.9	0.69	0.01	0.01	0.25
Kernels per ear, count	720	641	570	553	13	0.01	0.01	0.03
Stem width, mm	19.7	18.9	17.4	17.0	0.32	0.01	0.01	0.64

[1]55K = 55,000 plants/ha; 70K = 70,000 plants/ha; 85K = 85,000 plants/ha; 100K = 100,000 plants/ha.
[2]Trt = treatment; L = linear response; Q = quadratic response.

Ferreira and Teets (2017) *Prof. Anim. Sci.*

Corn Planting Density
On-farm Studies – 7 fields from VA

Table 3. Effect of planting density on nutritional composition (DM basis) of fresh corn

	Planting density[1]					P < [2]		
Item	55K	70K	85K	100K	SEM	Trt	L	Q
Ash, %	3.5	3.7	3.7	3.7	0.07	0.17	0.11	0.14
CP, %	10.2	10.2	10.3	10.3	0.12	0.90	0.61	0.85
NDF, %	36.5	38.0	38.2	38.2	0.54	0.09	0.04	0.17
ADF, %	21.6	22.3	23.0	22.7	0.39	0.11	0.04	0.24
ADL, %	2.4	2.5	2.4	2.2	0.13	0.35	0.16	0.27
Starch, %	33.4	34.4	33.5	33.5	0.48	0.46	0.72	0.27
Sugars, %	12.3	12.4	12.7	11.5	0.34	0.15	0.15	0.07
30-h IVNDFD,[3] % of NDF	45.9	43.9	42.4	43.8	1.08	0.12	0.12	0.14

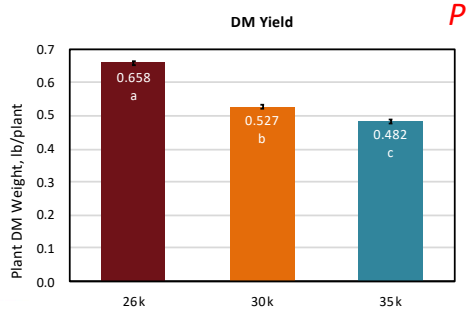
[1]55K = 55,000 plants/ha; 70K = 70,000 plants/ha; 85K = 85,000 plants/ha; 100K = 100,000 plants/ha.
[2]Trt = treatment; L = linear response; Q = quadratic response.
[3]IVNDFD = ruminal in vitro NDF digestibility.

Ferreira and Teets (2017) *Prof. Anim. Sci.*

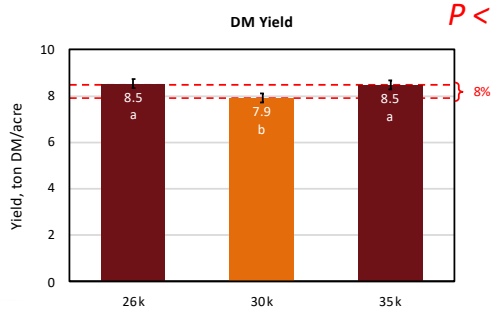
Southern SARE
On-Farm Research Program

- Hypothesis
  - Increasing corn plant population can increase the recycling of N and P through the soil-crop system
- Objectives
  - Determine yield and nutritional quality of corn silage
  - Determine the extraction of N and P by corn silage
  - Monitor residual N and P in the soil

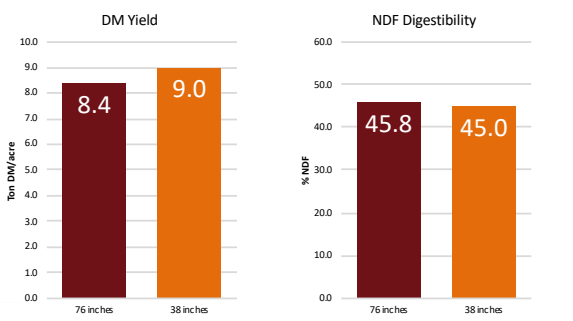
Corn Planting Density and P Extraction
Plant DM Weight – Planting Density



Corn Planting Density and P Extraction
DM Yield – Planting Density

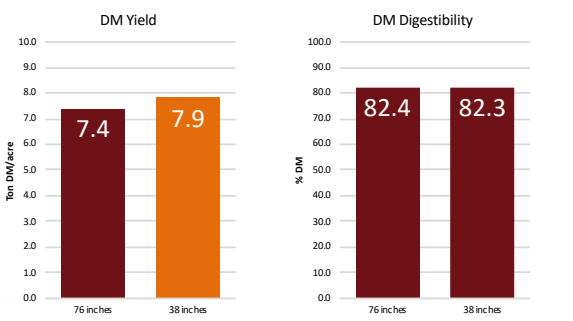


Pre-harvest Factors
Row Spacing



Cox and Cherney (1999) *Agronomy Journal*

Pre-harvest Factors
Row Spacing



Cox et al. (2006) *Agronomy Journal*

Pre-harvest Factors
Summary

- Heat stress can affect nutritional quality as much as drought
- Corn planting density
  - More yield with minimal (if any) changes in quality
- Narrow rows
  - Marginal increases in milk yield
  - Marginal changes (if any) in quality

Thanks!