Importance of Tissue Sampling and What We Learned in 2018

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“Guiding Producers today to feed the world tomorrow”

Plant tissue Sampling

- Sample 15 individual plants for a composite sample
- Consider stage of growth of any plant or crop
- Most recently developed leaf is the common sample to take
- When the ear shoot emerges sample the leaf at the ear
- For wheat and other small grains take the whole plant
- Try to sample before or at reproductive stage or at end of foliage growth
  - Soybeans blooms and grows at the same time so you can sample until blooming stops


Top leaf with a collar from 15 plants

Most recent mature trifoliate without petiole. Take 15 sets of trifoliate leaves

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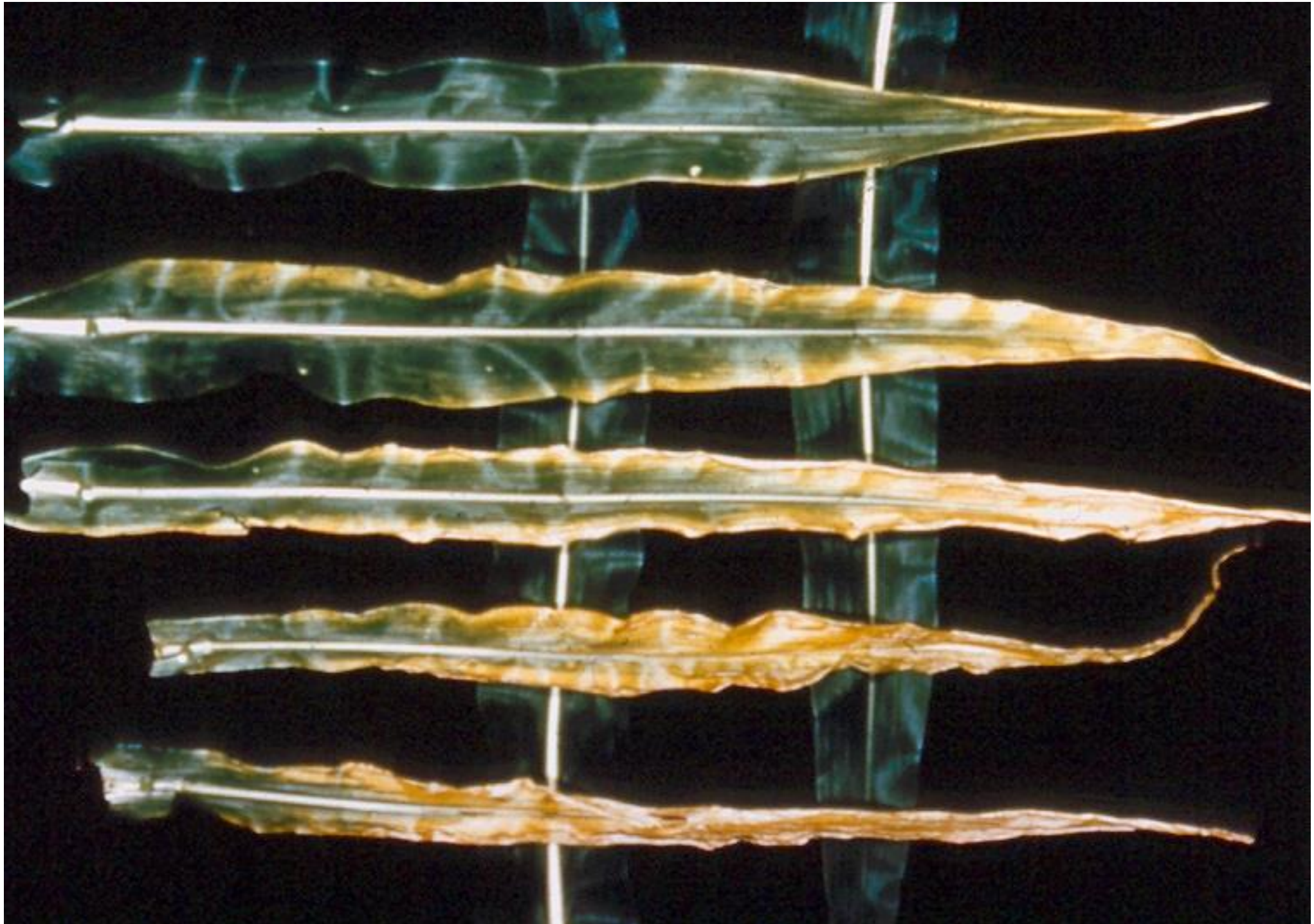
- Place plant samples in paper bags for shipping or bringing to the lab.

Mobility of Plant Nutrients

Very Mobile	Moderately Mobile	Slightly Mobile
Nitrogen	Magnesium	Iron
Phosphorus	Sulfur	Manganese
Potassium	Molybdenum	Copper
Chloride		Zinc
		Calcium
		Boron

Potassium

- **Potassium**, unlike other nutrients, K does not form compounds in plants, but remains free to 'regulate' many essential processes ... including enzyme activation, photosynthesis, water use efficiency, starch formation, and protein synthesis.
- **Symptoms** — Most common K deficiency symptom is scorching or firing along leaf margins. Since K is mobile in the plant, deficiency symptoms appear on older leaves first.



Potassium Sufficient Levels for Corn

Leaf Stage	% Sufficient range
3 – 5	2.5 – 3.5
6 – 9	2.3 – 3.5
10 – 14	2.2 – 3.0
15 - 18	2.1 – 2.6
Tassel	2.0 – 2.6
Grain Fill	1.7 – 2.6

Corn – Potassium, % in each category

Category	2017	2018
Deficient	1	1
Low	6	8
Sufficient	40	58
High	48	32
Excessive	5	2

Magnesium

- **Magnesium** activates more enzyme systems than any other nutrient and serves as a component of chlorophyll.
- **Symptoms** — Since Mg is a mobile nutrient in plants, deficiency appears first on older leaves as yellowing or interveinal chlorosis.

Magnesium Sufficient Levels for Corn

Leaf Stage	% Sufficient range
3 – 5	0.15 – 0.40
6 – 9	0.15 – 0.40
10 – 14	0.15 – 0.36
15 - 18	0.15 – 0.36
Tassel	0.15 - .036
Grain Fill	0.13 – 0.40

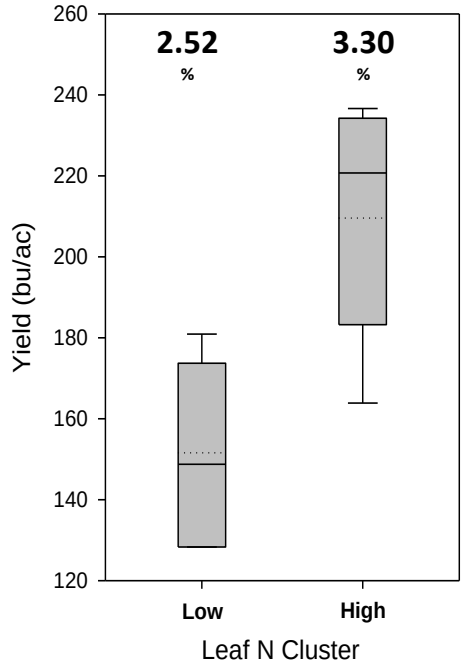
Corn – Magnesium, % in each category

Category	2017	2018
Deficient	1	8
Low	25	44
Sufficient	70	45
High	4	2
Excessive	1	0

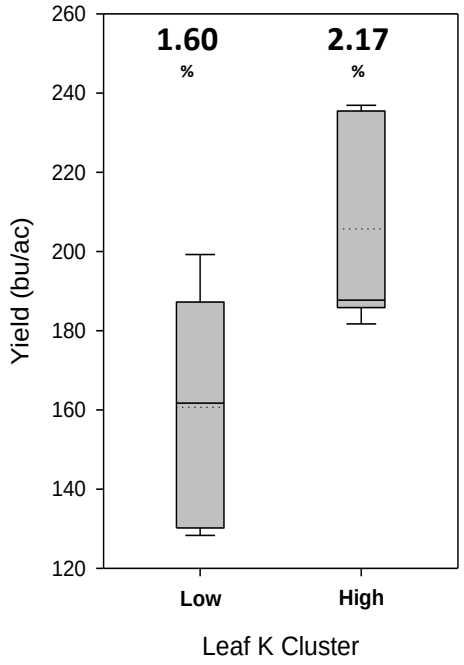
2014 Ear Leaf Nutrients Cluster Analysis

Box Whisker plot nutrient cluster[1] comparisons
Variable grain yield – 2014, 16 sites, cluster size 5 sites each

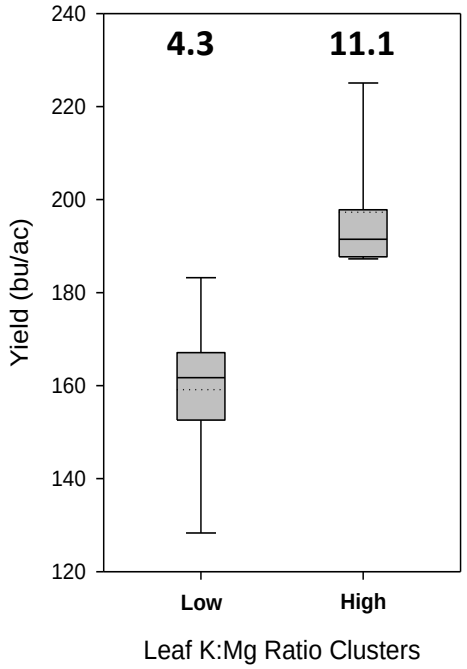
Leaf N



Leaf K



Leaf K:Mg



[1] Cluster analysis based on five lowest sites and highest sites for each test parameter (Leaf N, K and K:Mg), response variable grain yield, 8 reps per site.

Miller et al, 2017

Summary: Ear Leaf K Cluster Analysis

131 sites, 2011 – 2016 cluster mean comparisons

Year	*Mean Ear Leaf Low K cluster* [1]		*Mean Ear Leaf High K cluster*		Yield Difference
	K %	K:Mg	K %	K:Mg	Bu/ac
2011	1.77	5.9	2.64 *	11.1 *	40.5
2012	1.52	3.2	1.91	6.7 *	58.2 *
2013	1.67	3.0	1.95	8.3 *	34.6
2014	1.60	4.8	2.17 *	10.2 *	49.5 *
2015	-	-	-	-	-
2016 [2]	1.47	3.6	2.93 *	14.2 *	44.1 *

*[1] Clusters comparisons five sites in 2011, 2012 and 2014; four in 2013; and eight 2016. Insufficient data 2015, five sites. * values are significant at the 0.05 level.*

[2] 2016 Data based on 46 sites, seven states.

45.2 ← **Five year mean**

Cluster comparisons show mean leaf K and K:Mg ratios are different.

Cluster yield differences were consistent.

Miller et al, 2017

K:Mg ratio importance (Elwali et.al. AJ 1985)

- Potassium:Magnesium ratio should be 10+/-6 (4 to 16).
- Magnesium was pretty low in 2018. But the K:Mg ratio indicates the low Mg values may not be as deficient based on the K:Mg ratio. Something we need to study more.

K:Mg Ratio 2018 (Elwali et.al. AJ 1985)

K:Mg ratio	% of Samples
Less than 4	1.4
4 to 10	15.3
10 to 16	20.5
Greater than 16	62.8

How bad is this high ratio?

Nitrogen

- **Nitrogen** is an integral part of all plant proteins. Thus the nutritive value of the food we eat is largely dependent on the availability of N for crop growth.
- **Symptoms** — Adequate N produces a dark green color in leaves, caused by a high level of chlorophyll. As a mobile nutrient in plants, deficiency symptoms appear first on older leaves as light green to yellow foliage.

Nitrogen Sufficient Levels for Corn

Leaf Stage	% Sufficient range
3 – 5	3.5 – 5.0
6 – 9	3.2 – 4.8
10 – 14	3.0 – 4.0
15 -18	2.8 – 3.5
Tassel	2.7 – 3.4
Grain Fill	2.5 – 3.4

Corn - Nitrogen, % in each category

Category	2017	2018
Deficient	2	2
Low	16	8
Sufficient	73	78
High	9	12
Excessive	0	0

Sulfur

- **Sulfur** is required in the plant for the formation of amino acids and proteins, and is essential to photosynthesis.
- **Symptoms** — Sulfur deficiency can sometimes be confused with N deficiency. Deficient plants are light yellow green in color with the yellowing initially manifested in the younger leaves as S is immobile in the plant.

Sulfur Sufficient Levels for Corn

Leaf Stage	% Sufficient range
3 – 5	0.20 – 0.28
6 – 9	0.15 – 0.28
10 – 14	0.15 – 0.26
15 - 18	0.15 – 0.26
Tassel	0.15 – 0.26
Grain Fill	0.15 – 0.26

Corn – Sulfur, % in each category

Category	2017	2018
Deficient	0	0
Low	2	3
Sufficient	76	76
High	18	18
Excessive	4	3

N:S ratio importance (Elwali et.al. AJ 1985)

- Nitrogen-Sulfur ratio should be 12 +/- 3 (9 to 15). However, I like to use ratio of 16:1 as sufficient.
- Many times I have found sufficient S values in the tissue but N was so high that the N:S ratio could go to 30:1 or more. If N is very high and the plants look light green calculate N:S ratio.

N:S Ratio 2018 (Elwali et.al. AJ 1985)

N:S Ratio	% of samples
Less than 9	1.6
9 to 16	69.1
16 to 18	21.2
Greater than 18	8.1

Phosphorus

- **Phosphorus** is a vital component in the process of plants converting the sun's energy into food, feed, and fiber.
  - Phosphorus plays a key role in photosynthesis, the metabolism of sugars, energy storage and transfer, cell division, cell enlargement, and transfer of genetic information.
- **Symptoms** — The first sign of a P shortage is an overall stunted plant. Tissue may be dark green in color.
  - Older leaves are affected before younger ones because of the redistribution of P in the plant. Some plants, such as corn, may display a purple or reddish color on the lower leaves and stems.


0
10
20
40
LB P_2O_5 PER A

Phosphorus Sufficient Levels for Corn

Leaf Stage	% Sufficient range
3 – 5	0.35 - 0.55
6 – 9	0.28 – 0.50
10 – 14	0.26 – 0.38
15 -18	0.26 – 0.37
Tassel	0.25 – 0.35
Grain Fill	0.24 – 0.35

Corn – Phosphorus, % in each category

Category	2017	2018
Deficient	2	1
Low	7	4
Sufficient	70	64
High	21	31
Excessive	0	0

Zinc

- **Zinc** plays a key role in many enzyme systems in plants. It controls the production of important growth regulators that influence new growth and development, thus one of the first indications of Zn deficiency is the presence of stunted plants resulting from a shortage of growth regulators.
- **Symptoms** — Zinc deficiency appears as a chlorosis in the interveinal areas of new leaves, producing a banding appearance.

Zinc Sufficient Levels for Corn

Leaf Stage	% Sufficient range
3 – 5	20 - 60
6 – 9	20 - 60
10 – 14	19 - 60
15 - 18	19 - 60
Tassel	18 - 60
Grain Fill	20 - 50

Corn – Zinc, % in each category

Category	2017	2018
Deficient	0	6
Low	6	16
Sufficient	90	74
High	3	4
Excessive	0	0

P:Zn ratio importance (Elwali et.al. AJ 1985)

- Phosphorus ratio should be 113 +/- 40 (73 to 153).

- Since we have a lot of P values in the high range I looked at the P:Zn ratio. It appears maybe some of the Zn deficiency may be caused by very high P values.

P:Zn Ratio 2018 (Elwali et.al. AJ 1985)

P:Zn ratio	% of Samples
Less than 73	11.1
74 to 113	26.1
114 to 153	27.2
Greater 153	35.6

Iron

- **Iron** is a catalyst to chlorophyll formation and acts as an oxygen carrier in photosynthesis. It is essential to protein synthesis, plant respiratory enzyme systems, and energy transfer.
- **Symptoms** — Iron deficiency typically first appears as interveinal chlorosis of younger leaves due to its immobile nature in plants, and as the severity of the deficiency increases, chlorosis spreads to older leaves. Severe deficiency may turn the entire plant yellow-to-bleached white.

Corn – Iron, % in each category

Category	2017	2018
Deficient	0	0
Low	0	0
Sufficient	64	91
High	23	6
Excessive	13	3

Manganese

- **Manganese** functions primarily as part of plant enzyme systems. It has a role in several metabolic reactions, including the conversion of nitrate-N to a form the plant can use.
- **Symptoms** — Manganese is immobile in the plant, so its deficiency appears as reduced or stunted growth with visual interveinal chlorosis on younger leaves.

Corn – Manganese, % in each category

Category	2017	2018
Deficient	0	0
Low	2	1
Sufficient	90	94
High	7	4
Excessive	1	0

Copper

- **Copper** is a key element component of chlorophyll playing a central role in photosynthesis. Soil deficiencies are often associated with high organic matter soils, peats, and mucks since Cu is held more tightly by organic matter, thus making it less available for root uptake.

Corn – Copper, % in each category

Category	2017	2018
Deficient	0	0
Low	1	2
Sufficient	96	95
High	2	2
Excessive	0	0

Boron

- **Boron** is essential for growth and development of new cells in the new growth areas. Seed development, cell wall formation, flowering, nodule formation, and developing fruit all depend on adequate B.
- **Symptoms** — Boron is immobile in the plant and deficiency symptoms appear as abnormal growth on the youngest leaves and growing points with apical growing points eventually becoming stunted and dead.
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Corn – Boron, % in each category

Category	2017	2018
Deficient	1	0
Low	3	6
Sufficient	93	94
High	3	0
Excessive	0	0

Molybdenum

- **Molybdenum** is needed by the plant in the synthesis and activation of nitrate reductase, an enzyme which reduces nitrate to ammonium in the plant. It is also required for symbiotic fixation of N within legume root nodules.
- **Symptoms** — Molybdenum deficiency symptoms frequently resemble N deficiency. Older and middle leaves become chlorotic first, and in some instances, leaf margins are rolled and growth and flower formation is restricted.

Corn – Molybdenum, %

Category	2017	2018
Deficient	6	1
Low	19	6
Sufficient	42	77
High	29	14
Excessive	5	2

Calcium

- **Calcium** deficiencies are most likely to occur on acid, sandy soils from which available Ca has been leached, and on strongly acid peat and muck soils where total soil Ca is low.
- **Symptoms** - Leaves curl and margins turn brown with newly emerging leaves sticking together at the margins, leaving expanded leaves shredded on their edges.

Corn – Calcium, % in each category

Category	2017	2018
Deficient	1	1
Low	2	1
Sufficient	88	90
High	8	7
Excessive	1	2