Seasonal Corn Nutrient Concentration and Uptake in the Mid-Atlantic USA

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Introduction

Periodic assessment of corn (*Zea mays* L.) nutrient uptake and utilization is necessary to ensure high yields and efficient fertilizer use. Excess fertilizer applied to crops can be lost to the environment, so judicious use is important. In environmentally sensitive areas, including the Chesapeake Bay watershed, scrutiny of nutrient inputs, particularly nitrogen (N) and phosphorus (P) has increased and so while corn yields have risen, fertilizer input recommendations have generally not. Modern corn hybrids are producing greater yields under stress and many are maintaining green leaf area later in the season than older hybrids. These evolutions in corn production could all result in potential nutrient deficiencies in corn fields.

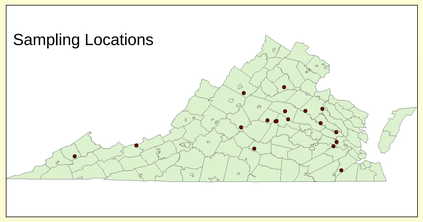
Objective

- Assess the range in nutrient concentration and uptake for corn grown in Virginia at various stages of development and link this to grain or silage yield.

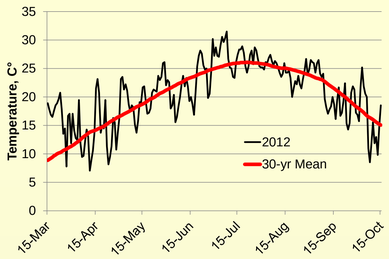
Materials and Methods

- Fields selected for high to moderately-high yield potential throughout Virginia were selected for study.
- Fields and study areas within fields were chosen soon after corn emergence with the intention of including the major soil types and corn growing regions in Virginia.
- All fields were planted in 76 cm rows; at the V4 and V12 sampling times, all plants in 5.3 m of row were counted in five random locations from the sampling area to estimate plant population.
- Fields were sampled at V4, V8, V12, VT, 3-weeks post-silking, and black layer (maturity, R6).
- At each sampling time, twenty representative plants were cut at the soil level and weighed. At V4 only data for whole plants were collected, but for subsequent sampling, data were collected by plant part (leaf, stem, spike) by separating and weighing each component separately after total weight was collected.
- At black layer, in addition to separating into plant parts, grain was shelled, weighed, and grain moisture determined using a DICKEY-john GAC 2100 (DICKEY-john, Auburn, IL).
- Nutrient uptake values were calculated as the product of dry matter biomass and nutrient concentration.
- Additionally, the most recently mature leaf (V8 and V12) or the ear leaf (VT) was collected from 20 separate plants to provide comparison of the tissue concentration in normally sampled plant part for evaluation at those sampling times.
- A&L Eastern Labs provided their complete data collection of corn tissue nutrient concentrations from the past 5 growing seasons' samples.
- Both Virginia Tech and A&L determine tissue N concentration via dry combustion while sulfur, phosphorus, potassium magnesium, calcium, sodium, boron, zinc, manganese, iron, copper and aluminum in tissue samples were measured by ICP-AES after microwave digestion using concentrated HNO_3+H_2O_2.
- The Proc Corr program of SAS 9.3 (SAS, Cary, NC) was utilized to detect correlations between various early season nutrient contents with grain content or yield.

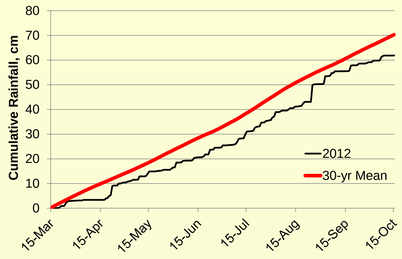
Summary and Results



2012 & 30-year mean average daily temperatures, Virginia

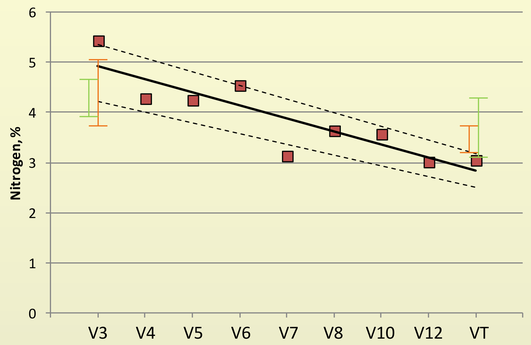


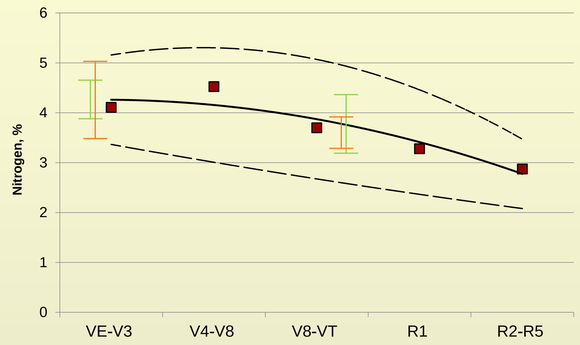
2012 & 30-year cumulative rainfall, Virginia

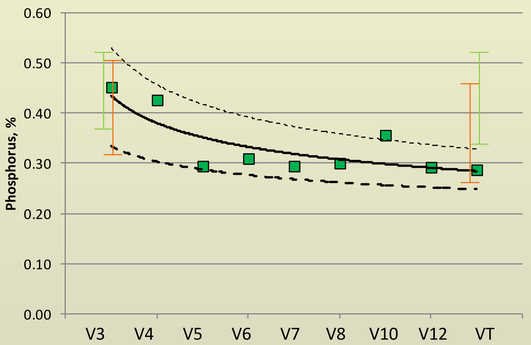


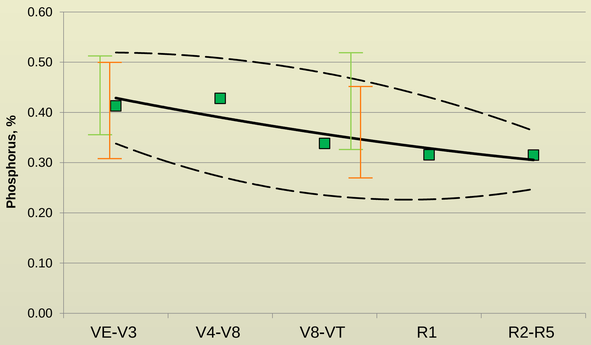
Mean corn tissue nutrient concentration of N, P, & K

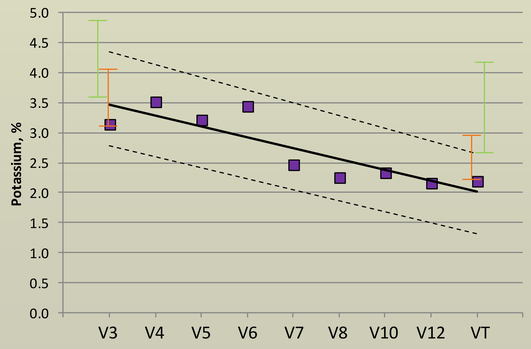
Right graphs: All A&L samples from Virginia at the V3 through R5 growth stages. Left graphs: 2012 samples from 11 sites in Virginia at the V3 through VT growth stages. Upper dashed lines represent the trend of the maximum values, lower dashed lines represent the trend of the minimum values, solid lines represent the trend of the mean values. Orange bars represent the recommended range per Virginia Tech. Green bars represent suggested range per A&L Eastern Labs. Separate thresholds exist for V2-V3 and V4-VT nutrient recommendations.

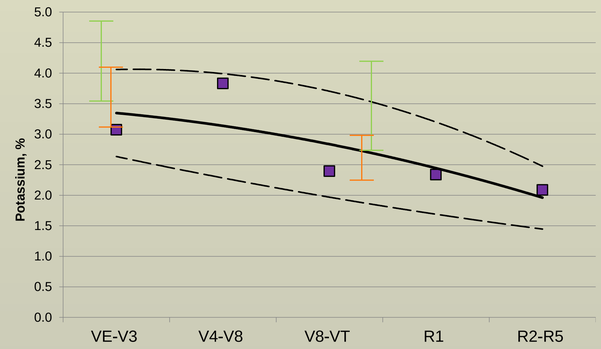








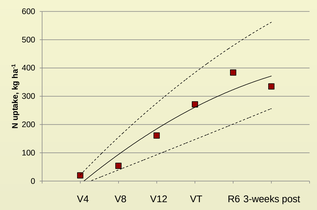


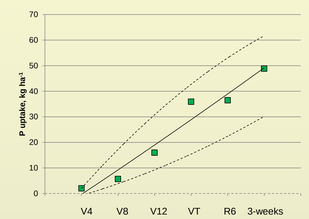


All pairwise Pearson correlations for V4, V8, V12, and grain nutrient concentrations of N, P, and K, and grain yield. Yellow boxes indicate significant interactions (p<0.05). Chart values represent Pearson's r values.

Pearson Correlation Coefficients, N = 11, *N = 10 Prob > |r| under H0: Rho=0	Whole Plant N, V4	Whole Plant P, V4	Whole Plant K, V4	*Leaf N, V8	*Leaf P, V8	*Leaf K, V8	Leaf N, V12	Leaf P, V12	Leaf K, V12	Grain N	Grain P	Grain K	Grain Yield
Whole Plant N, V4	1.00	0.43	0.20	0.41	-0.13	-0.38	0.38	0.50	0.06	0.45	0.30	0.51	0.39
Whole Plant P, V4		1.00	0.50	0.24	-0.27	-0.46	-0.10	0.47	0.69	0.24	0.21	0.25	0.05
Whole Plant K, V4			1.00	0.10	-0.39	0.20	0.07	-0.05	0.13	0.36	0.46	0.50	0.15
***Leaf N, V8**				1.00	0.38	-0.05	0.00	0.01	-0.09	0.39	0.25	0.43	-0.47
***Leaf P, V8**					1.00	0.34	0.28	0.28	-0.29	0.10	-0.01	0.09	-0.15
***Leaf K, V8**						1.00	-0.04	-0.40	-0.20	-0.23	-0.25	-0.17	0.37
Leaf N, V12							1.00	0.34	-0.62	0.62	0.63	0.69	0.24
Leaf P, V12								1.00	0.28	0.16	0.14	0.21	0.28
Leaf K, V12									1.00	-0.45	-0.52	-0.48	0.23
Grain N										1.00	0.93	0.96	-0.22
Grain P											1.00	0.93	-0.31
Grain K												1.00	-0.14
Grain Yield													1.00

Corn tissue nutrient uptake over locations at the V4 through three weeks post black layer; upper dashed lines represent the trend of the maximum values, lower dashed lines represent the trend of the minimum values, solid lines represent the trend of the mean values.





Conclusions

- The summer of 2012 was abnormally hot in late June and early July. Corn yield potential was reduced by the extreme weather. Cumulative rainfall was below the 30-year average for the entire growing season.
- Concentration of N, P, & K declined as plants matured, as expected.
- Early season nutrient concentration measured in these samples was generally within the range recommended by both Virginia Tech and A&L Eastern Labs.
- Late season whole plant nutrient concentration in these samples was at the low end of the recommended ranges recommended by both Virginia Tech and A&L Eastern Labs.
- A&L Eastern Lab database samples encompass their suggested critical values for late season N, but tend to be below critical values for P and K.
- Over locations, whole plant biomass peaked at physiological maturity at over 20 Mg ha^{-1} and fell by 4 Mg ha^{-1} at three weeks post maturity.
- Similarly, N uptake peaked at physiological maturity, though we observed that P uptake continued to increase at three weeks post maturity.
- Grain yield varied from approximately 4 to 17 Mg ha^{-1} over sites in 2012. This reflects the impact of drought and heat that was experienced to various degrees among the experimental sites.