What Can We Learn From CEC and Base Saturation?

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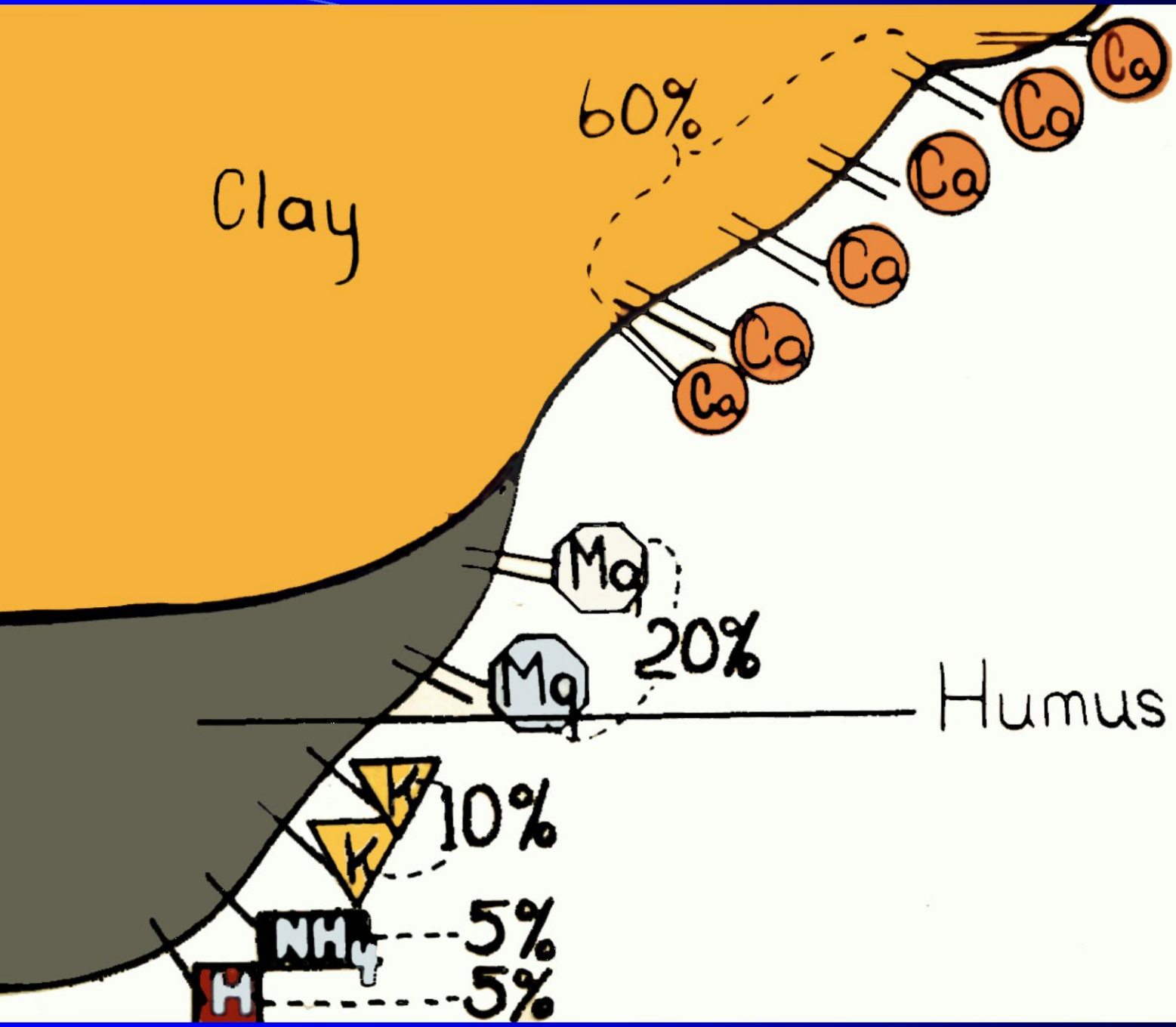
What Is Cation Exchange Capacity?

- In fundamental terms, this permanent soil property is a measure of the relative number of negative electrical charges in soils; reported as milliequivalents per 100 grams of soil (m.e./100gm) (cmole/100 grams)

Two Sources of Electrical Charges

- clays; CEC increases as % clay increases
- soil organic matter; not proportional to % soil organic matter


Clay
60%
Ca
Ca
Ca
Ca
Ca
Ca
Mg
Mg
20%
Humus
H
H
10%
NH4
5%
H
5%

AGVISE Gypsum project-Soil 1:

Gypsum Rate $CaSO_4$	pH	salt	Ca ppm	Mg ppm	K ppm	Na ppm
0 lb/a	7.50	.24	2460	390	551	20
300 lb/a	7.53	.32	2570	400	573	20
6000 lb/a	7.30	.92	3040	390	557	20
18000 lb/a	7.30	1.17	4290	400	563	25
36000 lb/a	7.37	1.31	6000	440	550	20

Routine ammonium acetate method used to determine Ca, Mg, K, Na

Salt level increasing due to gypsum addition. Salt level will increase each year gypsum is added if drainage is poor.

Increasing calcium ppm level due to dissolved calcium from the gypsum in the soil Solution being included in the test value. The soil is not actually holding more calcium.

AGVISE Gypsum project-Soil 1:

Gypsum Rate	%Ca	%Mg	%K	% Na	CEC
0	72%	19%	8%	0.5%	17
300 lb/a	72%	19%	8%	0.5%	18
6000 lb/a	76%	16%	7%	0.5%	20
18000 lb/a	81%	13%	5%	0.4%	26
36000 lb/a	86%	10%	4%	0.3%	35

The % calcium increases due to the dissolved calcium in the soil solution from the gypsum being included in the soil test value. The percentage of the other cations go down as the total of all the cations increases. The soil is not actually holding more calcium.

The true CEC of this soil is **18**, based on a testing method which does not Include calcium from salts already in the soil or in the gypsum applied.

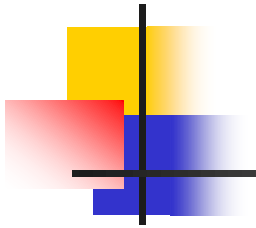
Routine ammonium acetate method used to determine Ca, Mg, K, Na

CEC and Soil Texture

Soil Texture	CEC (m.e./100 gm.)
clay loam	20-30+
silt loam	15-20
loam	12-15
sandy loam	10-12
loamy fine sand	less than 10

In Soils

- exchangeable Bases: Na+, K+, Ca++.and Mg++
- other positively charged cations: NH4,+ H+
- base saturation = sum of Na+, K+, Ca++, and Mg++ divided by CEC



- Na+ concentration divided by CEC = % saturated with Na+
- could be important in predicting severity of iron deficiency chlorosis
- otherwise, knowledge of % base saturation is not important in crop production

Calculations

- if concentration of an exchangeable basic cation is known along with CEC, it is possible to calculate % of exchangeable sites occupied by each basic cation
- then, some believe that ratios are important

Ca:Mg Ratios in Minnesota Soils

- vary over a wide range
- very high in western MN; low to high in eastern MN
- some low organic matter sandy soils require Mg in a fertilizer program
- the basis for the debate over calcitic and dolomitic limestone

Some History

- initial research conducted by Bear and co-workers in New Jersey using acid coastal plain soils from 1945 to 1947
- for "ideal soil" it was suggested that % of exchange sites occupied should be 65% Ca, 10% Mg, 5% K, and 20% H
- this converts to ratios of 13:2:1 for Ca, Mg, and K or 6.5 to 1 for Ca and Mg

History (con't)

- in Missouri, Graham (1959) relaxed the "ideal saturation" to 65 % to 85 % for Ca, 6 % to 12 % for Mg, and 2% to 5% for K
- published a bulletin providing a general description of soil testing theory. No data presented to support the suggested "saturation"

Corn Yields in Ohio

Relative Yield	Corn (75)	Corn (76)
	Ca:Mg ratio	
5 Highest Yielding Sites	5.7 to 26.8	5.7 to 14.3
5 Lowest Yielding Sites	5.8 to 21.5	5.0 to 16.1

Soybean Yields in Ohio

Relative Yield	Soybean (77)	Soybean (78)
	Ca:Mg ratio	
5 Highest Yielding Sites	5.7 to 14.0	5.7 to 26.8
5 Lowest Yielding Sites	2.3 to 16.1	6.8 to 21.5

Ca:Mg Ratio and Alfalfa Yield — Silt Loam Soil

Ratio	Yield
	ton D.M./ acre
2.28	3.3
4.76	3.4
8.44	3.2

Theresa silt loam is a Wisconsin soil

No Yield Difference due to wide range of "ratio"

Ca:Mg Ratio and Alfalfa Yield – Loamy Fine Sand

Ratio	Yield
	ton D.M./acre
2.64	4.1
4.81	4.1
8.13	4.4

Plainfield loamy fine sand is a Wisconsin soil

No Yield Difference due to wide range of "ratio"

Ca:Mg and Soybean Yield

Lime Source	Mg Rate	Yield
	lb. Mg./acre	bu./acre
none	0	42.4
calcitic	0	46.0
calcitic	300	46.3
dolomitic	0	49.3
dolomitic	300	46.3

Lime rate = 3500 lb. ENP /Acre initial pH = 5.6
Ca:Mg ratio = 4.1

Ca:Mg and Alfalfa Yield (total)

Lime Source*	Mg Applied	Yield
	lb./acre	ton D.M./acre
calcitic	0	2.24
calcitic	300	2.08
dolomitic	0	2.30
dolomitic	300	2.31

Lime rate for both sources was 3500 lb. ENP per acre

Ca:Mg Ratio After One Year

	Rate of ENP, lb./acre			
source	1750	3500	5250	0
	----------ratio----------			
none	--	--	--	5.3
calcitic	4.3	4.6	4.0	--
dolomitic	2.6	6.6	7.8	--

initial = 4.1; ENP = lb. Effective Neutralizing Power/acre

One Summary of the Concept

- " the values suggested bu Bear, Pierce, and Malcolm (1945), Graham, (1959), and Amacher (1981) all represent a good educated guess regarding satisfactory exchangeable cation ratios in most soils for most crops. The fact is, though, that research has not documented that there is an optimum exchangeable cation ratio for any crop….."
- Dr. Charles Black….Iowa State University

Can Products Affect CEC?

- NutrAsyst
- improves fertilizer efficiency
- improves soil Cation Exchange Capacity
- improves soil and plant moisture retention
- can be impregnated on dry fertilizer
- A blend of low molecular weight organic acids

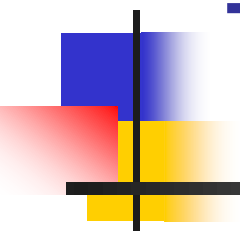
Value of CEC and Base Saturation

- CEC provides an indication of soil texture
- base saturation does not affect fertilizer guidelines
- exchangeable Na may help with the IDC problem

Summary

- CEC is a nearly fixed soil property; measure once
- CEC is really a measure of soil texture
- base saturation related to soil acidity
- exchangeable Na+ may be important in IDC
- cation ratios have no impact on crop production

Questions, Comments, Concerns?



Thank You For Your Attention