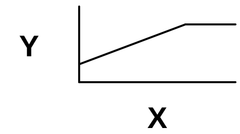
Agronomy 354
Soil Fertility
Growth Response Curves

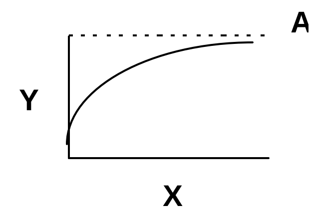
Liebig (c. 1860, German)
(linear)



$Y = mX + b$

where:
- Y = yield.
- m = slope - i.e. rate of yield increase. It is a function of the environment and nutrient.
- X = amount of nutrient added.
- b = minimum yield, one would get this yield with no nutrient additions.

Mitscherlich (c. 1910, German)
(Law of Diminishing Returns)



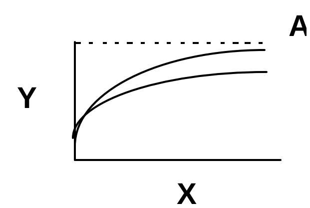
(1) $dy/dx = (A-Y)C$

if integrate equation (1), then get

(2) **$\log(A-Y) = \log(A) - cX$**

where:
- A = maximum possible yield (theoretical).
- Y = actual yield.
- dy/dx = slope - i.e. rate of yield increase. It is a function of the environment, the nutrient, **and amount of nutrient already present.** This value gets smaller as nutrient amount increases.
- x = amount of nutrient added.
- c = constant.

Bray (c. 1920, U. Illinois)
(soil interactions)



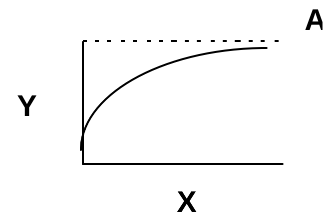
Started with Mitscherlich's basic equation, developed:

$\log(A-Y) = \log(A) - c_1B - cX$

where:
- A = maximum possible yield (theoretical).
- Y = actual yield.
- dy/dx = slope - i.e. rate of yield increase. It is a function of the environment, the nutrient, **and amount of nutrient already present.** This value gets smaller as nutrient amount increases.
- X = amount of nutrient added.
- c_1 = constant that is for B.
- c = constant.

B = value explaining behavior of 'immobile' nutrients (e.g. K, P, Ca, Mg). The c_1B term takes into account the reality that nutrients interact with soil and not all nutrients behave identically.

Baule (c. 1920, German mathematician, worked with Mitscherlich)
(nutrient interactions)



Baule developed idea of "half-way points."

Using the identical relationship as Mitscherlich,
Baule concluded that

$$Y = A - A(1/2)^{\#\ \text{Baule Units}}$$

where:
A = maximum possible yield (theoretical).
Y = actual yield.
# Baule Unit = the amount of nutrient that when added results in moving Y (yield) one-half way closer to A (maximum possible yield).

Practically, this equation says when one Baule Unit of a nutrient is added, then yield increases 50% of the difference between current yield and possible yield. If a second Baule Unit is added, then yield increase will be 1/2-way closer to the maximum possible yield, so 2 Baule Unites would result in 75% of the maximum possible yield increase. If a third Baule Unit of a nutrient is added, move 1/2-way closer to the maximum possible yield, or 87.5% of the maximum possible yield would result.

THE ADVANTAGE OF BAULE UNITS BECOMES APPARENT WHEN DEALING WITH NUTRIENT INTERACTIONS.

For example, if one knew the soil contained 2 Baule Units of N and 3 Baule Units of P, one might think sufficient N was available to get 75% of the maximum possible yield and sufficient P was available to get 87.5% of the maximum possible yield. Consequently, one would estimate 75% yield if only one nutrient were limiting. In fact, a first approximation for nutrient interactions is that one would only get 66% of the maximum possible yield because as far as the plant is concerned you have too little N and too little P. The 66% is calculated by multiplying the 75% from N by the 87.5% from P.