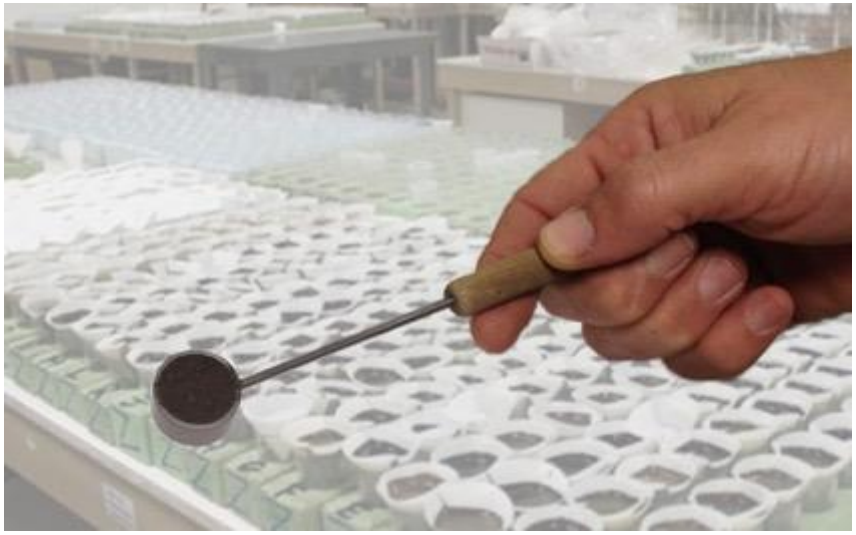
History of Soil Testing and Fertilizer Use

ILSOY Dec.11 2025

Tim Smith
Cropsmith Inc.

Current soil Testing
pulling sample, drying, grinding

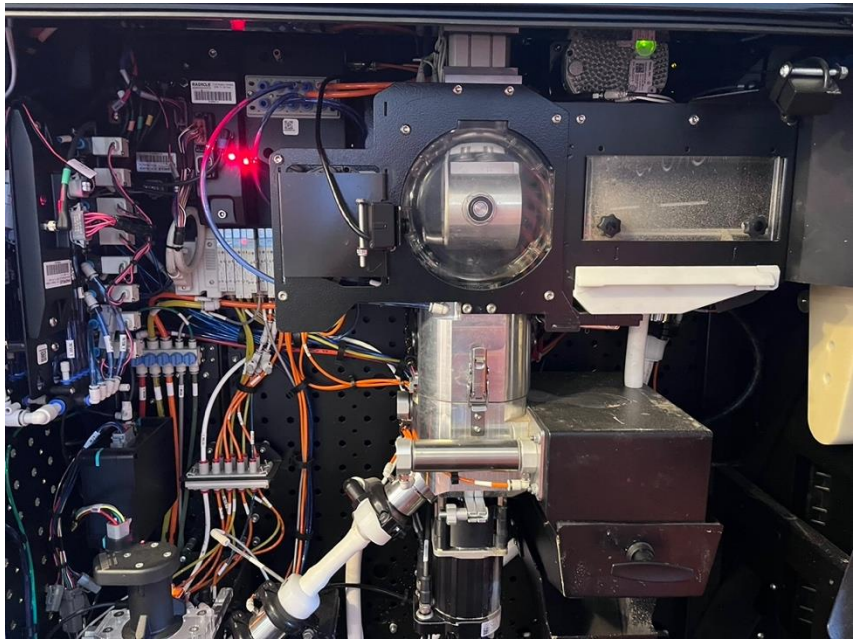
Scooping, Extracting, Filtering



ICP measurement of soil extract


RADICLE
AGRONOMICS

The future of Soil Testing?



GeoPress vs bag

Smith Farm 1930

I am Sterquillnus, Roman god of Fertilzer (Manure)

Luke 13:6

The Parable of the Barren Fig Tree

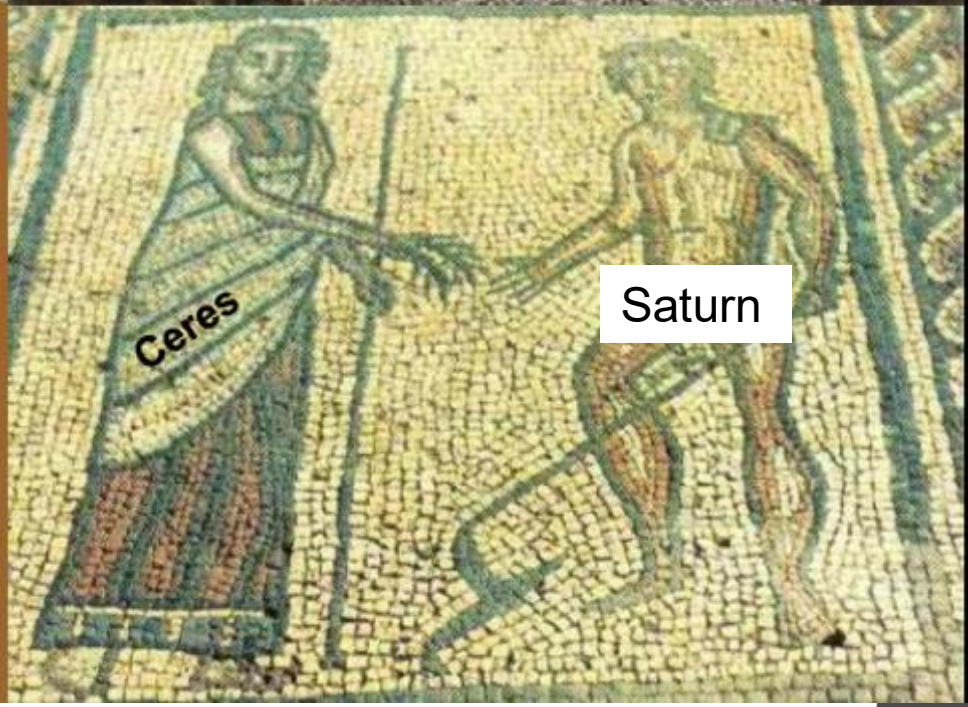
And he told this parable: “A man had a fig tree planted in his vineyard, and he came seeking fruit on it and found none. And he said to the vinedresser, ‘Look, for three years now I have come seeking fruit on this fig tree, and I find none. Cut it down. Why should it use up the ground?’ And he answered him, ‘Sir, let it alone this year also, until I dig around it and put on fertilizer (manure). Then if it should bear fruit next year, well and good; but if not, you can cut it down.’ ”

First 12,000 years of Fertilizer History

10,000–8000 BC	domestication of plants and animals began
1563	Bernard Palissy advocated for the use of fertilizers (manure)
1675	John Evelyn noted that rainwater contained 'celestial nitre'
1772	Daniel Rutherford discovered nitrogen; he receives credit because he published first
1772	Carl Scheele, Henry Cavendish, Joseph Priestley, concurrently and independently discovered nitrogen
1774	Joseph Priestley discovered nitrous oxide and ammonia
1785	C. L. Berthollet determined that ammonia is made up of nitrogen and hydrogen
1790	Jean Antoine Claude Chaptal officially named nitrogen
1823	Johann Wolfgang Döbereiner produced ammonia using a platinum catalyst
1824	Joseph Fourier was one of the first to describe the greenhouse effect
1836	Jean-Baptiste Boussingault identified nitrogen as a nutrient for plants
1838	Jean-Baptiste Boussingault determined legumes could fix their own nitrogen
1840	Justus von Liebig advocated the addition of certain nutrients to the soil for plant growth
1843	John Bennet Lawes and Joseph Henry Gilbert confirmed that nitrogen helps plants grow and that nitrogen comes from sources other than precipitation
1852	Robert Angus Smith connected the presence of acid rain with human activities
1856	Jules Reiset recognized that decaying matter releases N, providing the basis for the nitrogen cycle
1880	Herman Hellriegel and Hermann Wilfarth discovered the process of biological nitrogen fixation
1896	greenhouse effect was more fully quantified by Svante Arrhenius
1909	Fritz Haber synthesized ammonia from nitrogen and hydrogen gas
1913	Carl Bosch performed Haber's ammonia synthesis on an industrial scale

Roman art also reveals a lot about their agriculture.

In addition to Saturn and Ceres (Roman god and goddess of Agriculture), the Romans had a god of manure named Stercutius who was worshiped by old women and children.

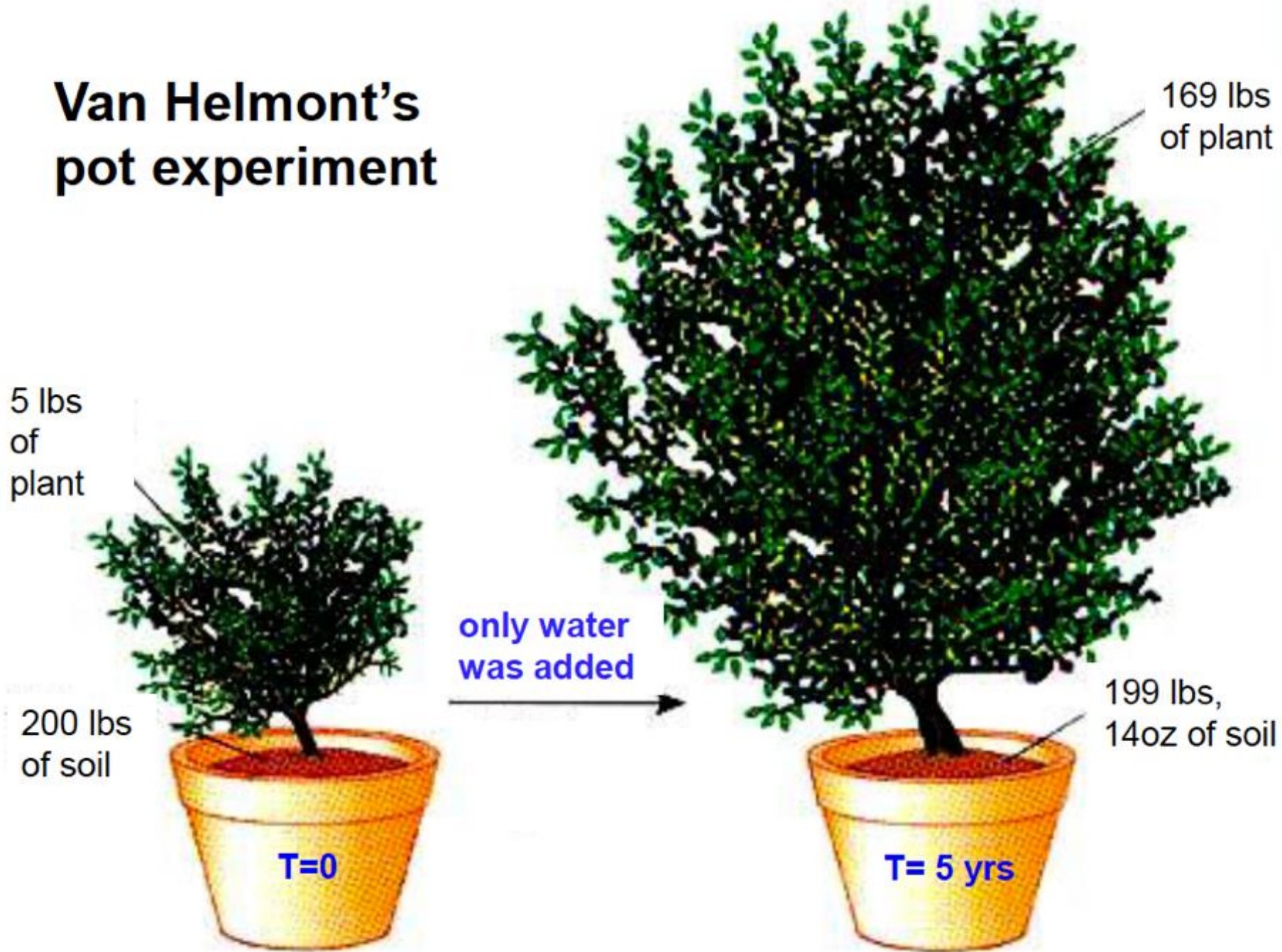


Bernard Palissy (1510-1589)
Ceramicist and hydraulic engineer

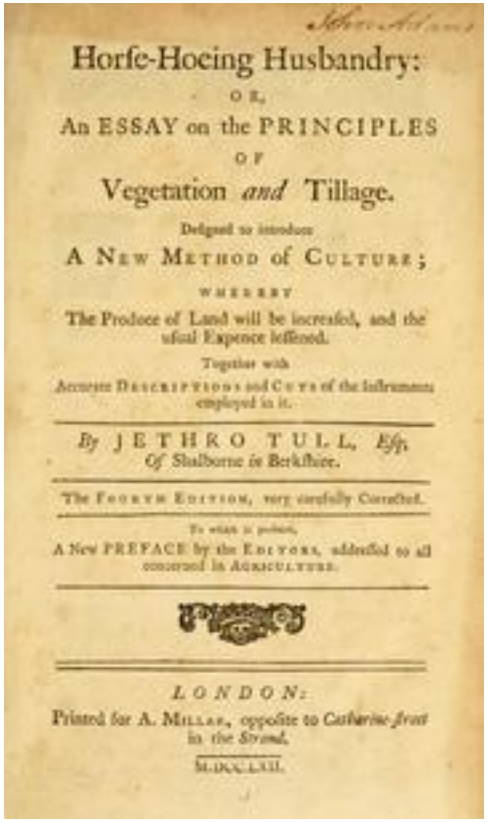
Far ahead of his time, Palissy wrote: "Manure is carried to the field for the purpose of restoring to the latter a part of what had been removed... Proceeding thus you will restore to the soil the same substances that have been removed by previous crops and which following crops will regain to their advantage."

Jean Baptista Van. Helmont (1577-1644)

Van Helmont's pot experiment



Jethro Tull 1674-1741



Horſe-Hoeing Husbandry:

OR,

An ESSAY on the PRINCIPLES

OF

Vegetation *and* Tillage.

Deſigned to introduce

A NEW METHOD of CULTURE;

WHEREBY

The Produce of Land will be increaſed, and the uſual Expence leſſened.

Together with

Accurate DESCRIPTIONS and CUTS of the Inſtruments employed in it.

By JETHRO TULL, *Eſq;*
Of Shalborne *in* Berkſhire.

The FOURTH EDITION, very carefully Corrected.

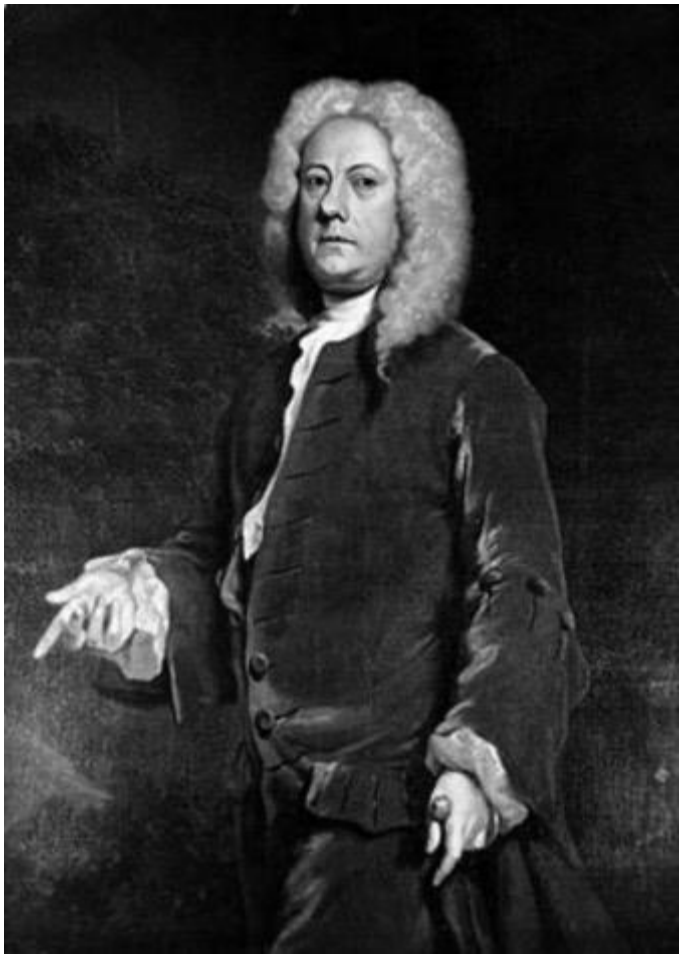
To which is prefixed,

A New PREFACE by the EDITOR, addreſſed to all concerned in AGRICULTURE.

LONDON:

Printed for A. MILLAR, oppoſite to *Catharine-ſtreet* in the *Strand*.

M.DCC.LXII.



Henning Brandt discovers phosphorus 1669

1.Goal: Brand wanted to find the Philosopher's Stone to turn base metals into gold.

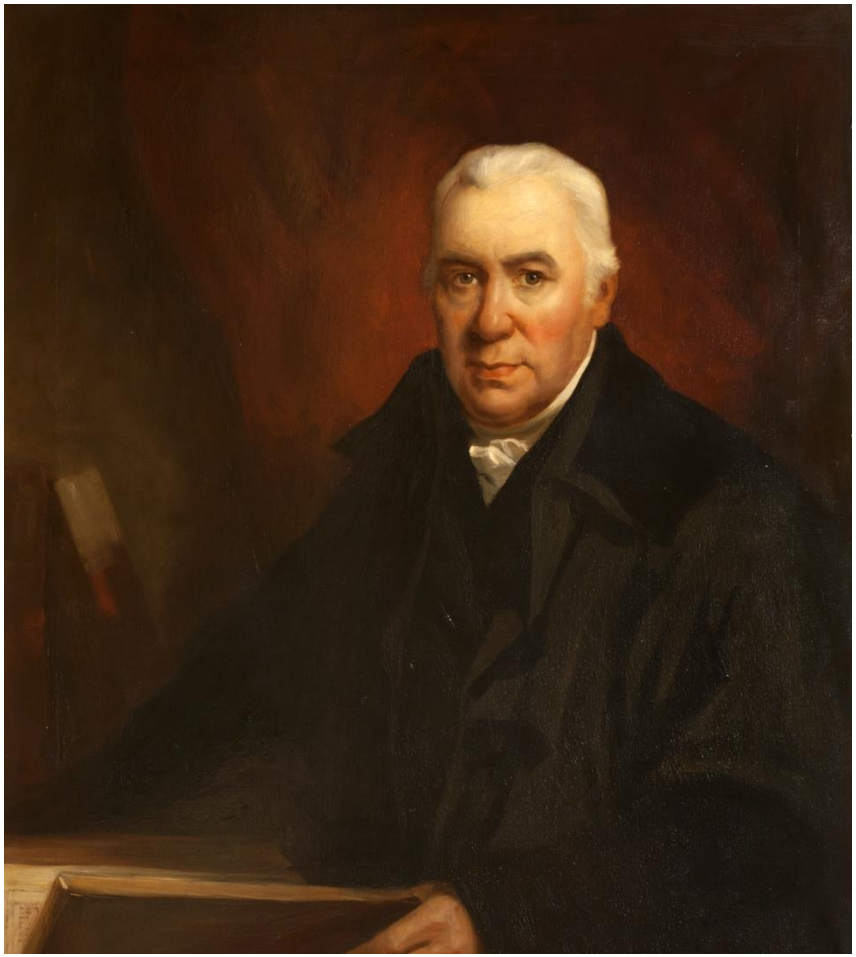
2.Material: He collected large quantities of human urine, believing it held precious metals.

3.Method: He fermented the urine, reduced it to a thick paste, and then heated it strongly (dry distillation).

4.Result: A white, waxy substance condensed, which glowed in the dark and ignited in air, leading Brand to name it "phosphorus" (light-bearer).

Humphry Davy, British chemist 1807

Daniel Rutherford Discovers Nitrogen 1772

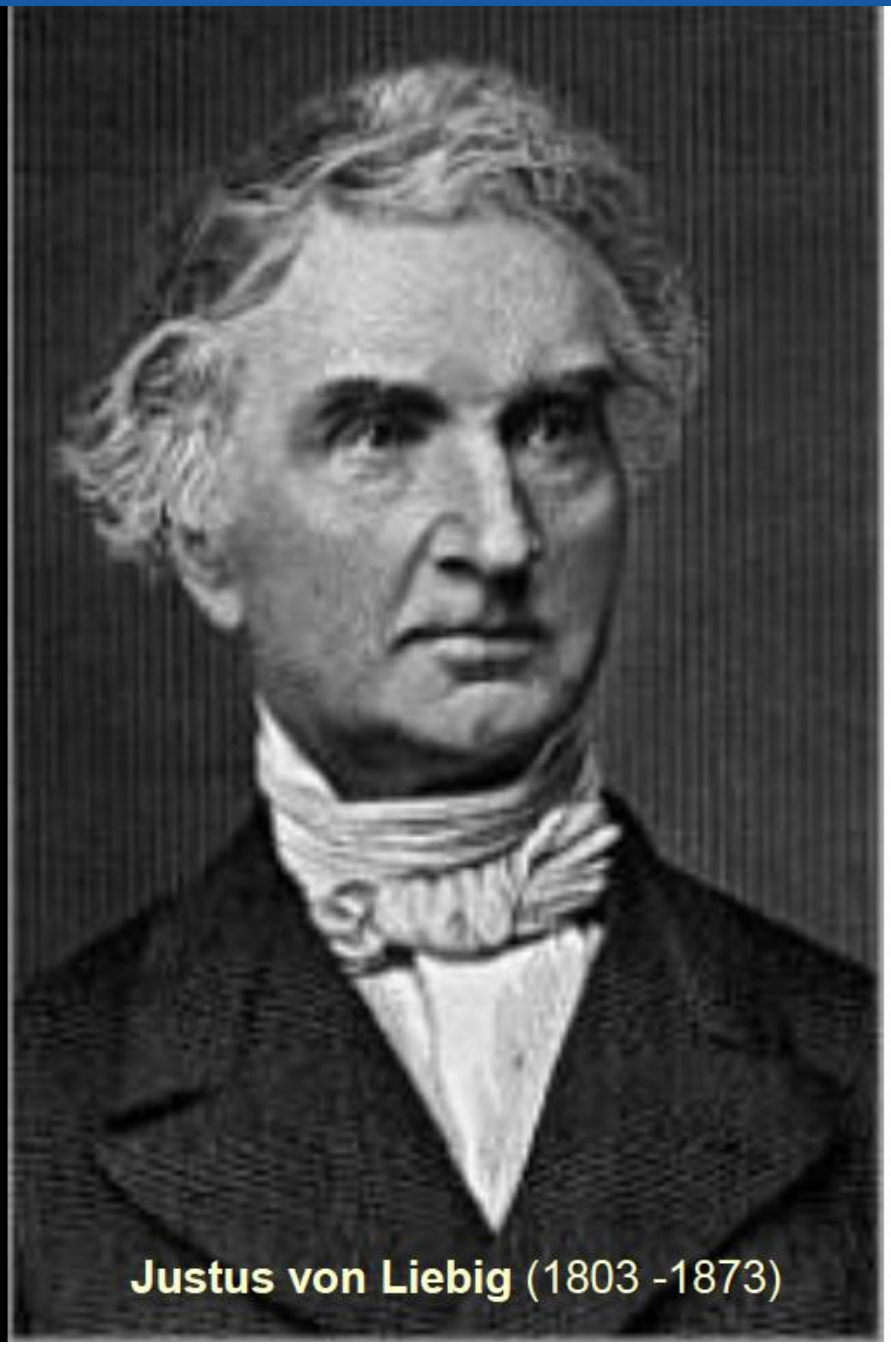


1.Experiment Setup: Rutherford placed a mouse in a closed jar until it died, then burned a candle and phosphorus in the remaining air, noting that these processes stopped, but the gas itself didn't support life or combustion.

2.Isolation: He then removed carbon dioxide from this gas by passing it through a lime-water solution, leaving behind the distinct, non-reactive gas.

3.Naming: He called it "noxious air" because it couldn't support life.

4.Jean Antoine Claude Cahpal named it nitrogen in 1790

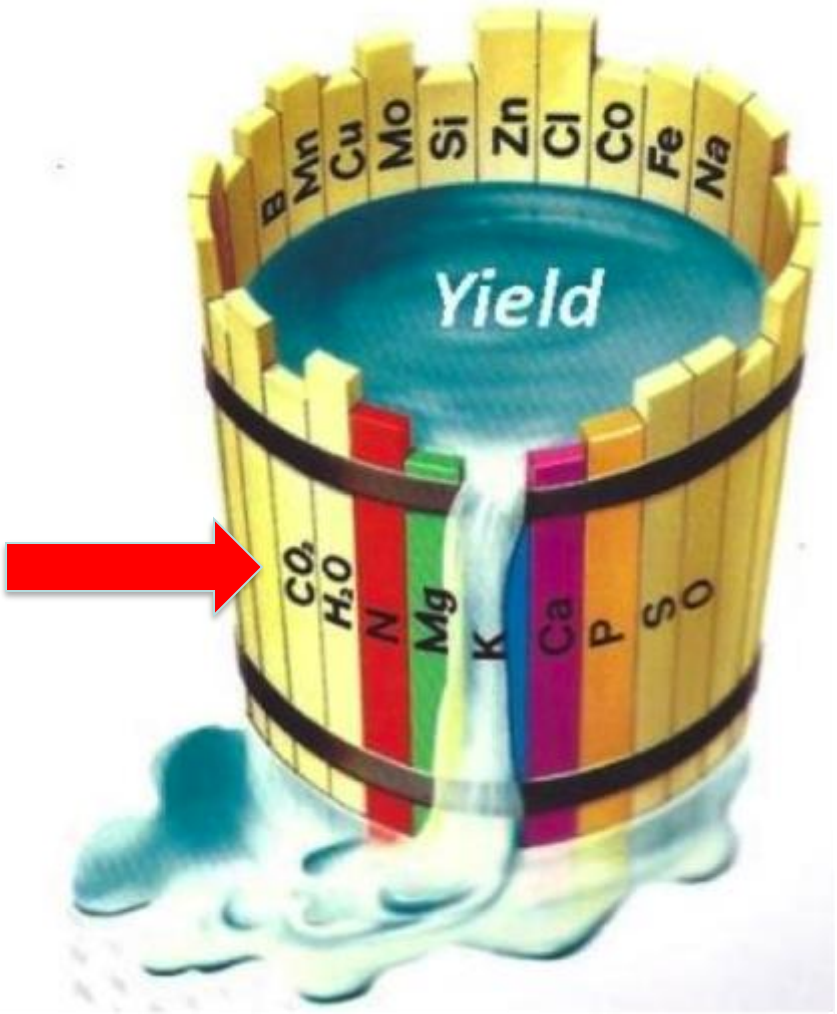


Justus von Liebig (1803 -1873)

Justus von Liebig
was a pioneering German chemist who wrote and lectured extensively about the mineral nutrition of plants. As the first professor to use the laboratory method of teaching chemistry, he is regarded as one of the greatest chemistry educators of all time.

He was held in such high esteem that few dared to question his pronouncements about mineral nutrition.

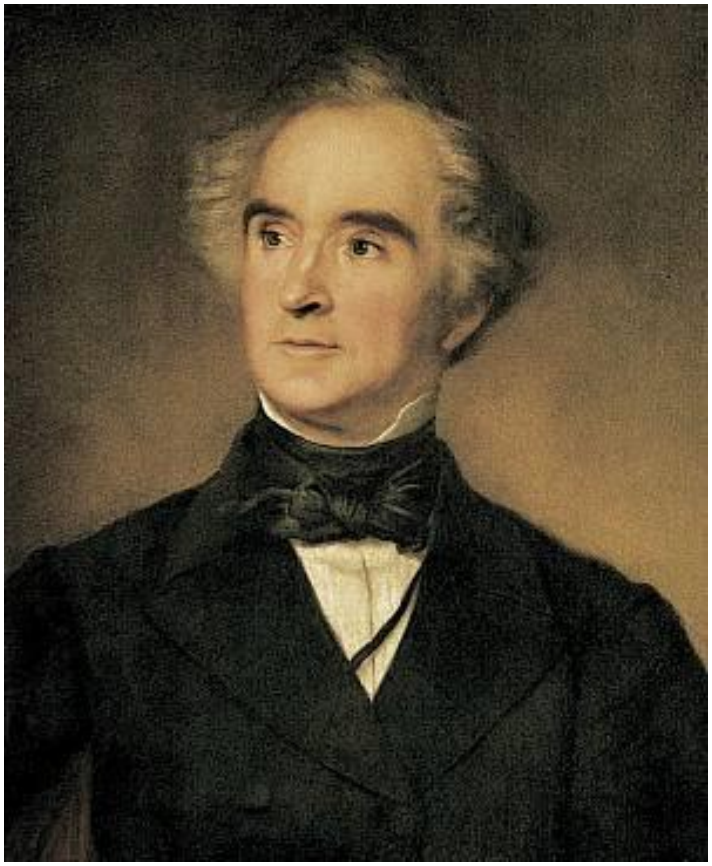
Lebig's Law of the Minimum? What about "Sprengel's Law of the Minimum"



Carl Sprengel (1787-1859)

Sprengel was the first to formulate the "theory of minimum" in agricultural chemistry, meaning that plant growth is limited by the essential nutrient at the lowest concentration.

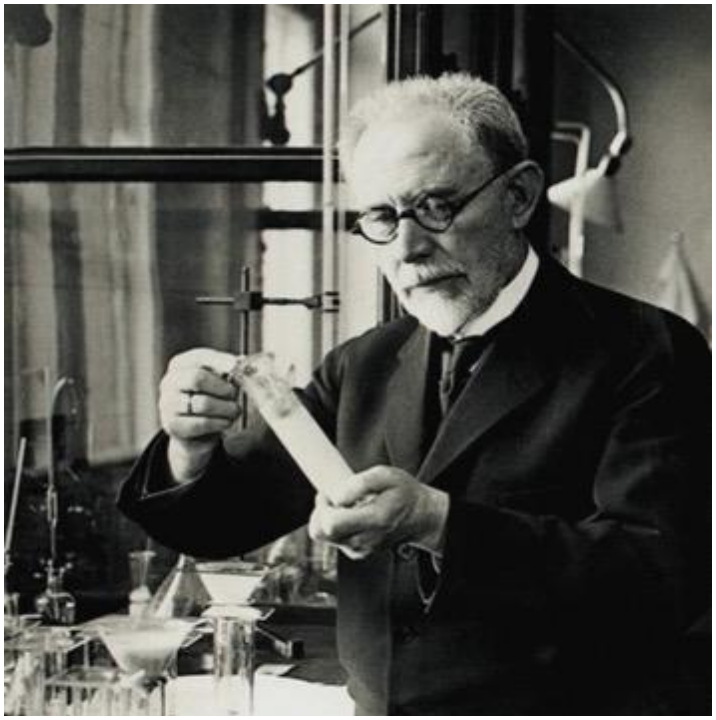
This rule, often incorrectly attributed to Justus von Liebig as Liebig's law of the minimum, was instead only popularized later as a scientific concept by Liebig.



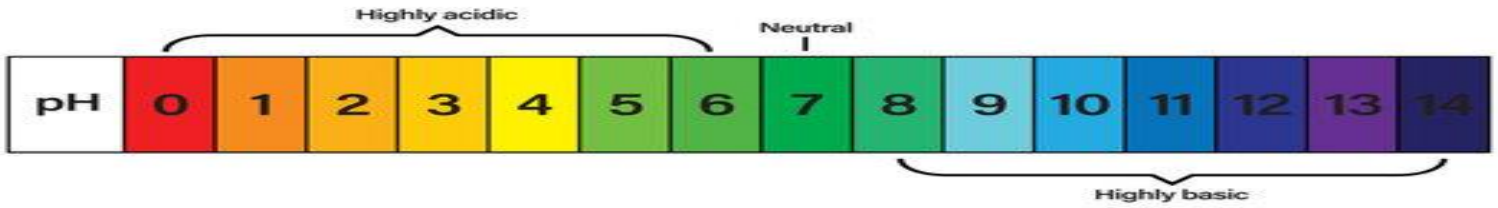
Mr Justus Liebig is no doubt a very clever gentleman and a most profound chemist, but in our opinion he knows as much of agriculture as the horse that ploughs the ground, and there is not an old man that stands between the stilts of a plough in Virginia, that cannot tell him of facts totally at variance with his finest spun theories.

— Magazine
The Southern Planter (1845),

Søren Peter Lauritz Sørensen 1868-1939



pH SCALE

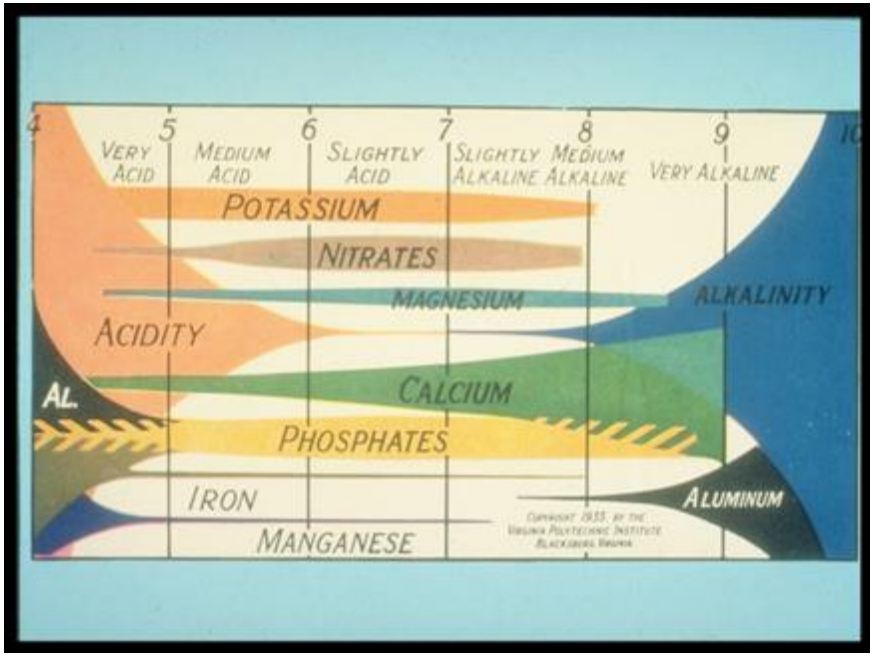


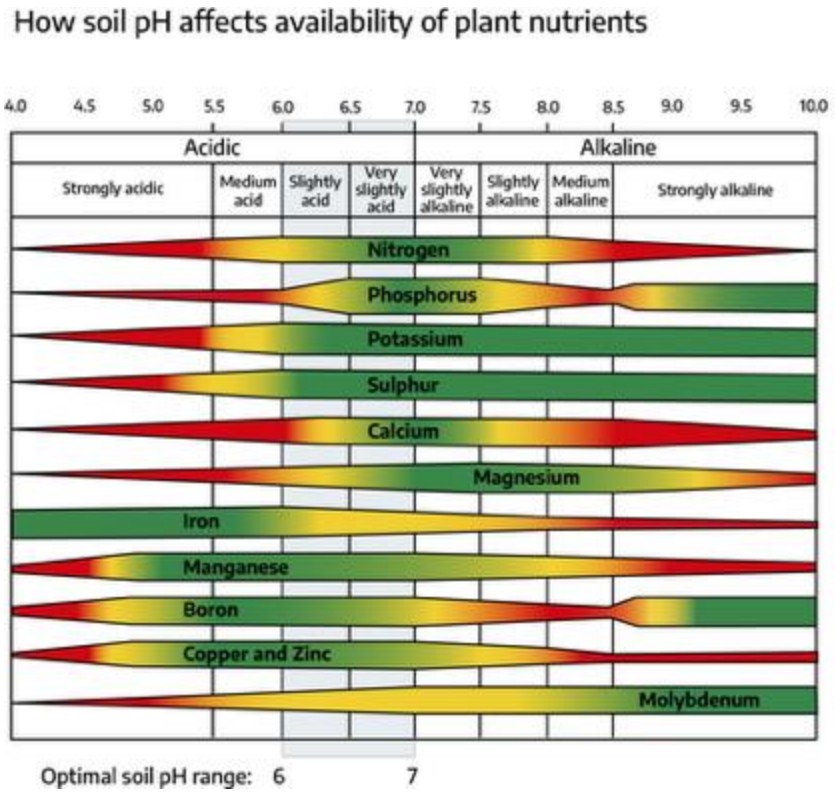
Arnold Beckman 1900–2004

From Collum IL.

1934

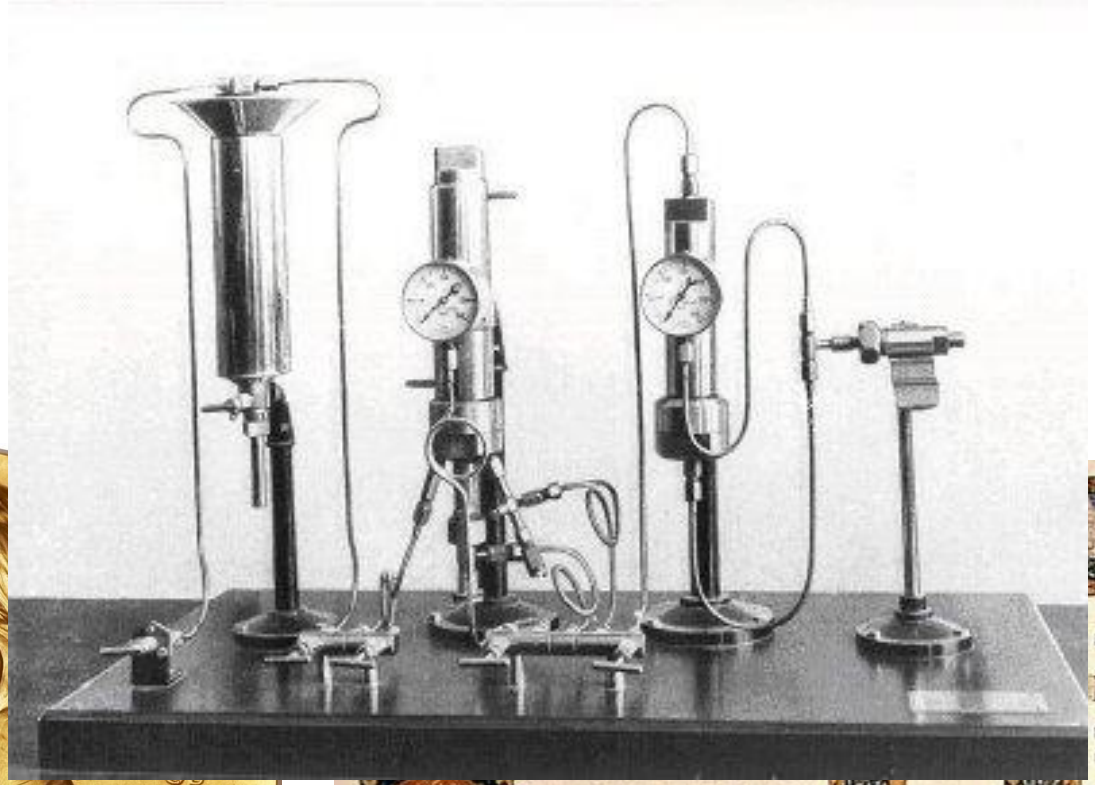
1935 vs today

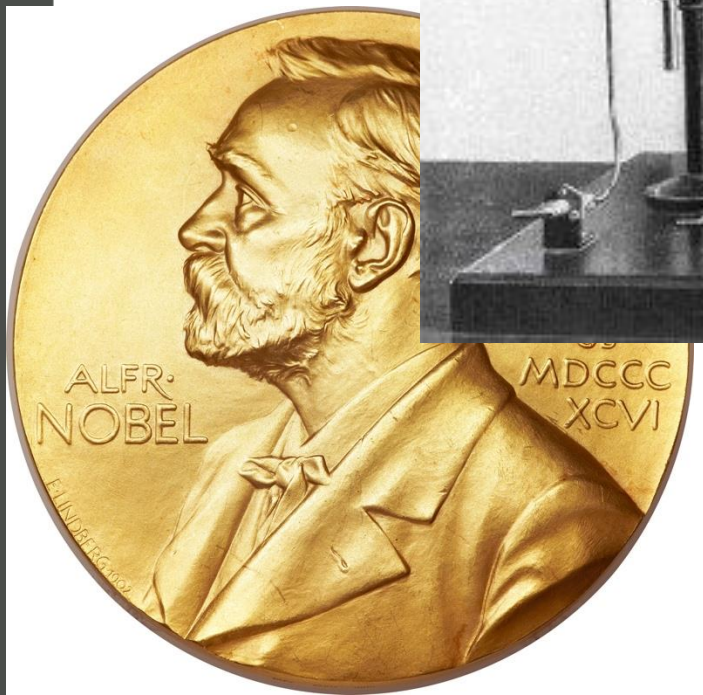


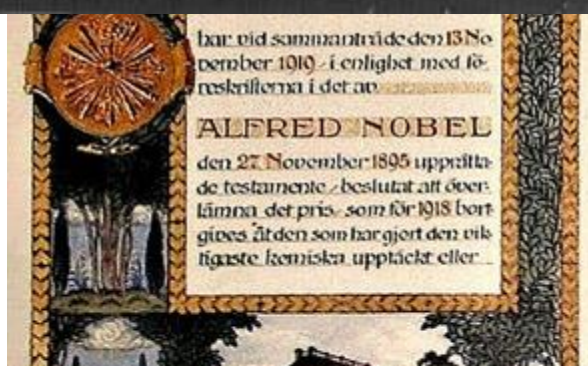


Fritz Haber Nobel Prize 1918

nitrogen synthesis

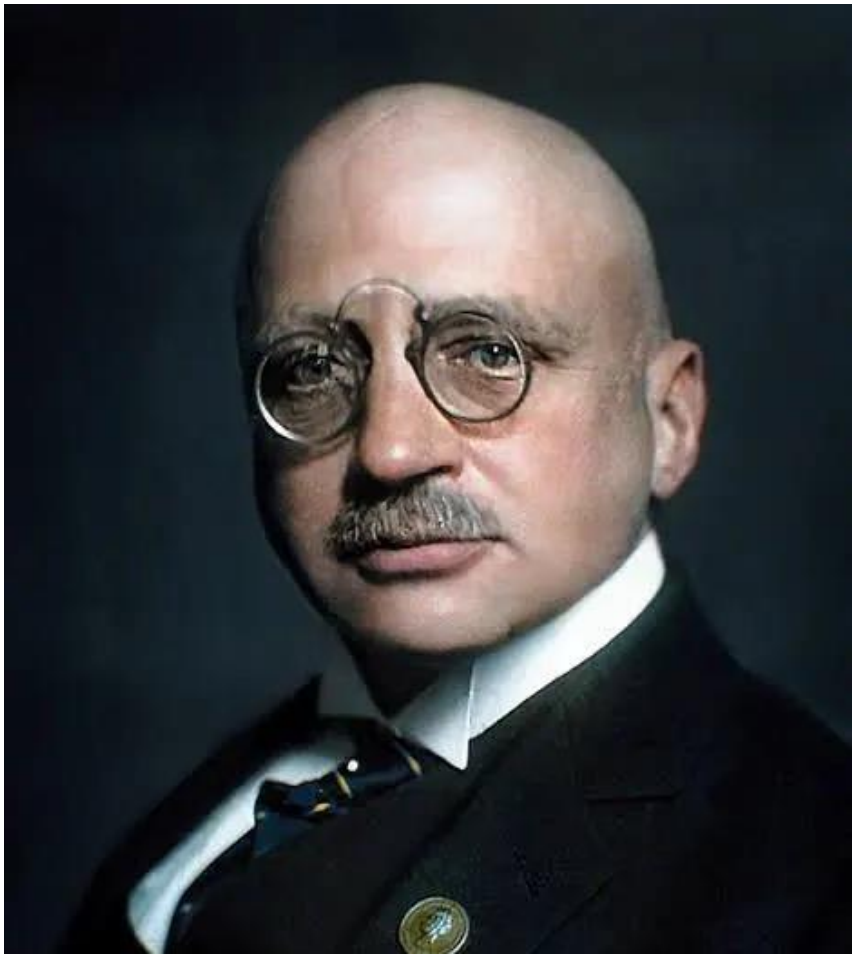






Fritz Haber 1886-1934

- **The Haber-Bosch Process (Feeding the World):** Haber synthesized ammonia from atmospheric nitrogen, creating a process to produce vast quantities of nitrogen fertilizer, preventing global famine and revolutionizing agriculture.
- **Father of Chemical Warfare (WWI):** During WWI, he directed Germany's chemical weapons program, deploying chlorine gas at Ypres, a horrific introduction of poison gas to warfare, which he actively supported.
- **Nobel Prize & Moral Compromise:** He won the 1918 Nobel Prize in Chemistry for his fertilizer process but faced deep moral condemnation for his war work, even as his wife committed suicide partly due to his role.
- **Tragic Jewish Scientist in Nazi Era:** A German Jew, he converted to Christianity but was ultimately targeted by Nazis, forced to flee Germany and dying in exile in Switzerland, broken by his nation's ideology.
- **Enduring, Complex Legacy:** His work remains central to modern life (fertilizers, explosives), making him a symbol of scientific duality – a man who fed the world while unleashing chemical horrors, a legacy debated today.



Evaluating Haber's Machine

Heinrich von Brunck
CEO of BASF

August Bernthsen
BASF Director of Research

Carl Bosch
BASF Chemist

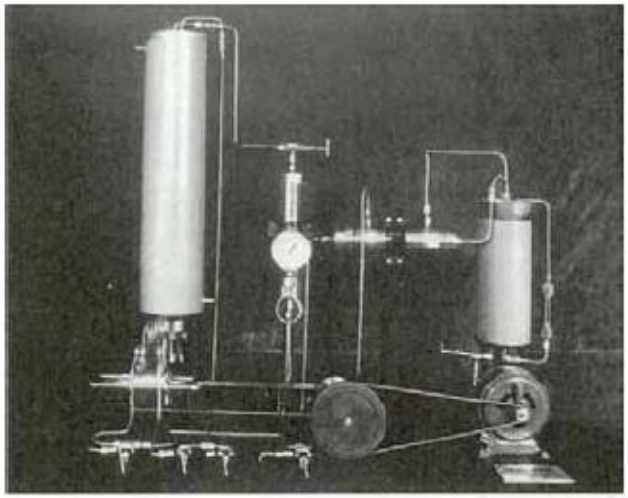


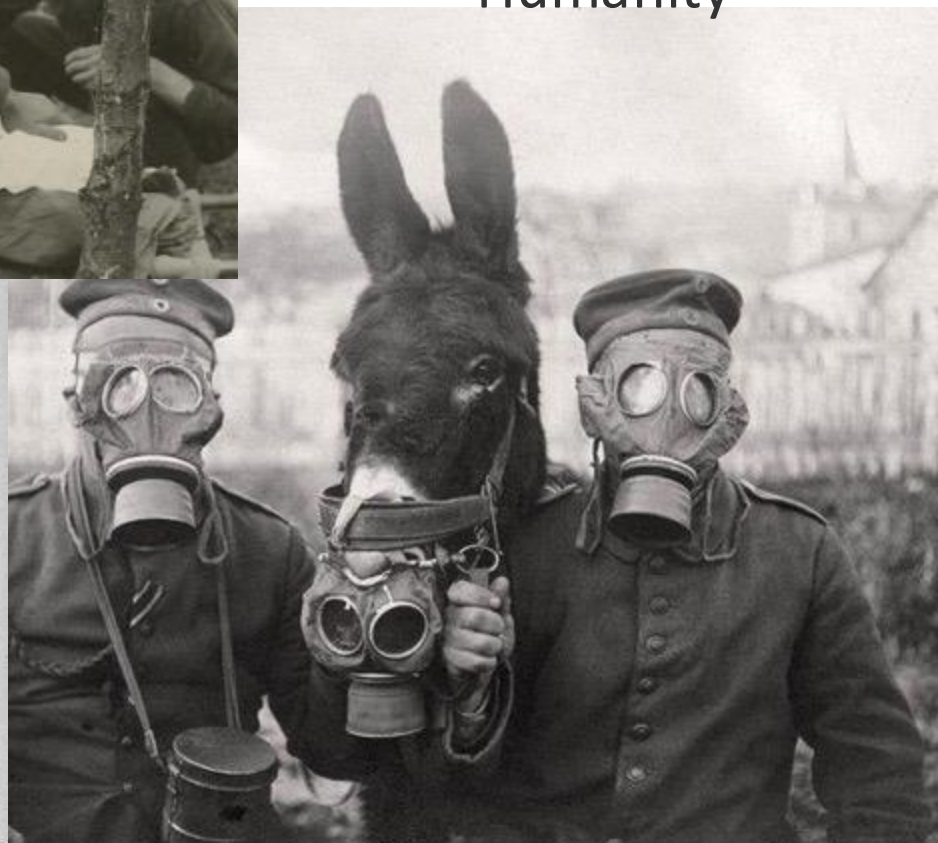
Abb. 4 Haber-Le Rossignol-Apparatur zur Ammoniaksynthese

Fritz Haber

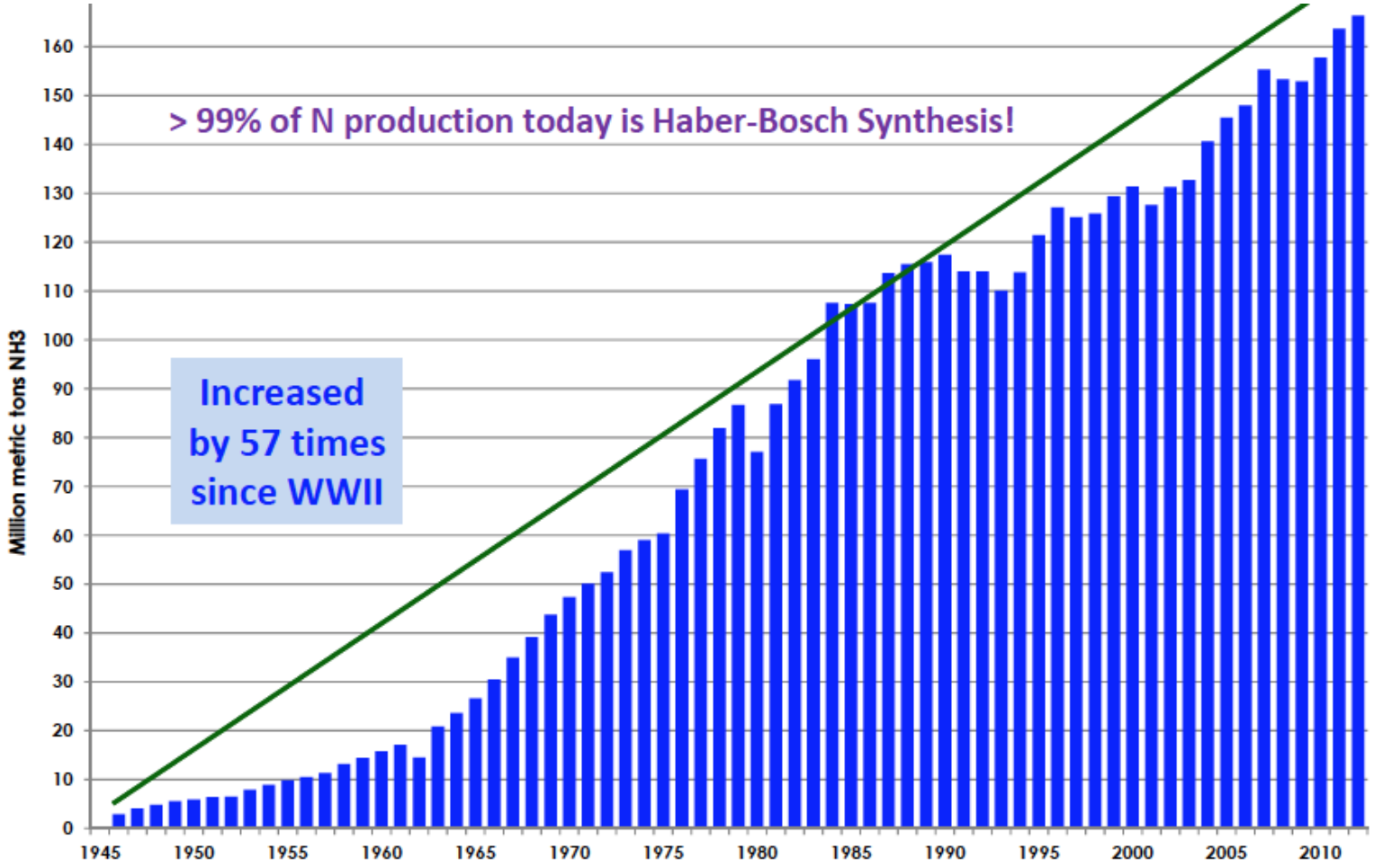
The Fertilizer Institute

Haber also invented products used in Chemical warfare

"Fritz Haber Was A Terrible Person Who Actually Saved Half Of Humanity"



That's a lot of Nitrogen



Norman Borlaug: Father of Green Revolution 1914-2009

Mineral Fertilizers were part of ”Green Revolution”

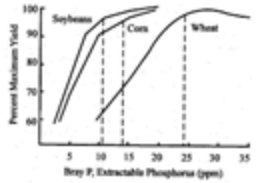
Nutrient Management Cycle

Crop

Soil Sampling

Soil Analysis

Recommendation



Application

Soil testing for assessment of fertilizer needs

How does a soil test work?

According to Roger Bray:

- Soil Test must reflect forms that are available to plant during growing season.
- Procedure must have reasonable accuracy and speed
- **"The amounts extracted must be correlated with the growth and response of each crop to that nutrient under various conditions."**

Requirements for Successful Soil Tests
Bray 1948

Roger H Bray 1889-1973

Fig. 23. Roger H. Bray, pioneer in developing methods for soil analysis.

Photelometer for Bray P1 1950's

July 7, 1951 Indiana Edition

PRAIRIE FARMER

DR. W. L. BURLISON and Dr. I. T. Kurtz look over the new $17,000 spectroscope now being installed at the University of Illinois. Dr. Burlison is the retiring head of the agronomy department, and Dr. Kurtz will supervise trace mineral research with the spectroscope.

America's Best

Soil Labs That Blanket Illinois Make One Third of All U. S. Soil Tests

IT'S EASY FOR an Illinois farmer to find out just what's in his soil. He has the nation's largest and best network of soil laboratories at his service.

And many are taking advantage of it. About one-third of the soil tested in the United States last year was tested in Illinois.

Close to 20 percent of the crop land in the entire state has been analyzed.

It all started like this. Dr. Roger H. Bray perfected tests for phosphorus and potassium in the thirties. University agronomists saw that farmers needed a place to send soil samples for accurate analysis.

So in 1943 a large laboratory was opened on the university campus. Farm advisers started encouraging farmers to send soil to the university lab. Then came the big change—the change that launched the nation's biggest soil testing program.

Frank Shuman, veteran Whiteside county farm adviser, came to the university in the fall of 1944 and said, "Look here. When we start our soils drive this fall, my Whiteside county farmers alone will swamp this lab!

"Why can't we have our own lab in each county, where a farmer can bring his soil right in, and actually see it tested?"

That's what happened. University soil chemists agreed to train local people to make accurate tests for lime, phosphorus, and potassium. A new (To page 34)

By RICHARD ALBRECHT

FARMERS NEED PHONE SYSTEM—READ HOW THEY GOT IT—PAGE 5

Cropsmith, INC.

Illinois Soil Lab System

(Continued from page 1)

ize-cost, "electric eye" color meter made it possible for a county Farm Bureau to fully equip a lab with all the testing equipment needed.

The Whiteside County Farm Bureau led the way, and set up the first county lab in 1944. A total of 51 counties opened similar labs the next year. Now Illinois has a network of 79 Farm Bureau soil testing stations.

The farm advisers are the key men in this setup. They supervise the labs, and make all the fertilizer recommendations. They are in a position to combine a knowledge of local soil conditions with technical training.

Twelve commercial and vocational agricultural labs, operating under the supervision of the university, complete the system. Some of them offer a more complete and personal service. Others fill in areas between the Farm Bureau labs and handle the samples from Farm Bureau members in some counties.

Take Two-Day Course

All technicians go through an intensive two-day training course at the central lab, under the supervision of A. U. Thor. But that isn't all. Thor keeps in close contact with the technicians by check-testing eight samples from each lab each month it operates.

"They are all doing an excellent job," he says. "But the monthly checks guard against a slipping of technique and the use of poor or deteriorated chemicals."

The costs for soil tests range from 50 to 70 cents per sample, with the majority now charging 50 cents. A "per acre" charge, usually 50 cents, is made when a complete farm study is made and specific recommendations are given. Four county Farm Bureau labs still make free tests for members, but Thor thinks they may soon be forced to change this policy.

The yearly reports from all these soil labs enable Thor to compile valuable and interesting figures on the fertility of Illinois soils.

He says 70 per cent of our farm land is still low in phosphate. About 50 per cent needs potash.

Over 60 million tons of limestone have been used to sweeten Illinois farm land since 1906. Limestone consumption now appears to be leveling off near five million tons a year.

Intelligent Use of Limestone

C. M. Linsley, extension soils man and chairman of the soil testing committee, says the use of the soil labs has greatly aided the intelligent use of limestone.

"Some people refuse their land too quickly—before it needs it," he says, "when they don't have a soil test made."

"The soil testing program has also shown our serious need for more potash in Illinois. It has greatly increased the demand for potash, but most farmers can't get all they need.

"So many are still on a potash-depletion system of farming."

Roger H. Bray, soils chemist, and another of the soil testing committee, are now working on ways to accurately calculate magnesium and other plant food deficiencies.

"You must remember that our present tests are incomplete," reminded Bray. "We are not yet testing for nitrogen, the third major element, and one which is limiting many crop yields today.

"We hope to be able to work out accurate interpretations for our present tests for nitrogen and organic matter. In the meantime, we have be a valuable guide in locating nitrogen deficiencies on growing crops."

In the tissue test, a chemical is brought into contact with a bit of juice or material from a growing plant, usually corn. The resulting color shows whether the plant is getting all the nitrogen it needs or not. Deficiencies show up on corn when it is growing most rapidly, usually in July and August.

Bray has very definite feelings about the importance of accurate soil tests to land owners and farmers.

"In fact, a land appraiser does a poor job for his client if he does not consider a recent soil test," he says. "The level of soil nutrients is part of the capital value of the soil."

A. U. Thor operates the central laboratory at the university, the nerve center for the 91 Illinois soils labs. He keeps a finger on their work, and knows just about what kind of a job each one is doing.

He warns that soil tests are just tools to use in proper soil management. They do not show the tilth or the organic matter content of a soil, and these may sometimes be the limiting factors in crop yields.

The history of the soil treatments is needed with a soil test before accurate fertilizer recommendations can be made. Limestone or rock phosphate applied within the last two or three years will not be mixed well enough with the soil yet to give an accurate reading in the test.

Thor has now trained 350 people to be soil testing technicians. About half of them have been women, and he says that middle aged women often make the best laboratory workers.

Trace Element Study

L. T. Kurtz, another member of the soil testing committee, is looking to the future, also. He is supervising the installation of a new spectroscope, to be used in the study of trace minerals.

"We know very little about trace minerals, yet," says Dr. Kurtz.

"This new spectroscope will enable us to study plant requirements for them, and test representative soil types for their trace mineral content.

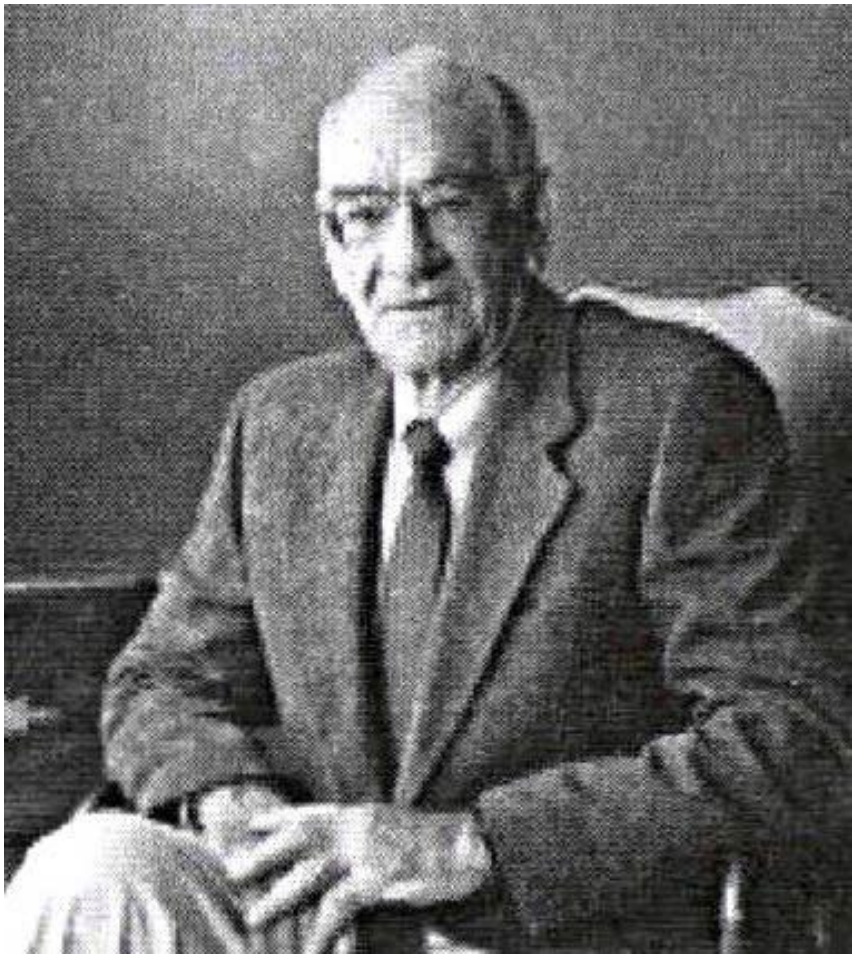
"Boron deficiencies have shown up on some southern Illinois alfalfa fields.

"Since yields go down quite a ways before trace mineral deficiency symptoms can be seen, it's important that our soils be studied for these minor but possibly crucial plant nutrients."

These scientists point out that it is as valuable to find out you don't need fertilizer or lime as to find out you need it!

This is especially important now because of the shortages of commercial plant foods. What fertilizer materials are available should be used carefully and efficiently. And the only way to do this is to have a complete soil test of your farm.

Ted Peck



- **Soil Scientist:** Dr. Peck was a leading figure in soil science at the U of I, working with the Extension service.
- **Advocate for Soil Testing:** He promoted rigorous soil analysis, emphasizing the university's role in research, development, and verification, contrasting with purely commercial labs.
- **Mentor:** He influenced many future agronomists, including those in the private sector, teaching ethics and agronomic principles.
- **Legacy:** He maintained a significant soil archive at the university, a resource continued by other researchers after his passing..

Ted Peck

Shelved and organized samples in the archive. Photo courtesy of Andrew Margenot.

Extractants for Modern Soil Testing

1945: Bray-1 P

Bray-1 was developed by **Dr. Roger H. Bray** and **L.T. Kurtz** for **acidic soils** in the Midwest, particularly Illinois.

1950s: 1M Ammonium Acetate

Base cation extract, not attributed to a single individual; **widely standardized by USDA & Cornell researchers**

1978: DTPA for Micronutrients

Introduced by **Lindsay and Norvell (not pictured) (1978)** to chelate micronutrients in **neutral to alkaline soils.**

2000s: Emerging Soil Health Tests

Extracts such as **H3A (Haney Test)** designed for **soil health assessment,** not yet widely calibrated to yield.

1 2 3 4 5 6 7

Olsen P, introduced in 1954 by **Dr. Sterling R. Olsen,** was designed for **alkaline and calcareous soils** common in the arid West.

1954: Olsen P

Developed by **Dr. Adolf Mehlich** for **sandy, acidic soils of the southeastern U.S.**, using strong acids (M-1: double acid; M-2: nitric + hydrochloric)

1970s: Mehlich-1 & -2

Developed as a **universal extractant for multiple nutrients (P, K, Ca, Mg, Na, S, Zn, Cu, Mn, Fe)** across a wider range of soils. Became the standard in many U.S. states.

1984: Mehlich-3

"The amounts extracted must be correlated with the growth and response of each crop to that nutrient under various conditions." Roger Bray

"Various conditions" means when you change:

- Tillage
- Crop rotation
- Row width
- Population
- Cultivar or variety (hybrid vs open pollinated

You should adjust your soil test calibration for your production system!

- Where do Illinois current soil test calibrations come from ?

Current Agronomy Handbook
Fertility Recommendations

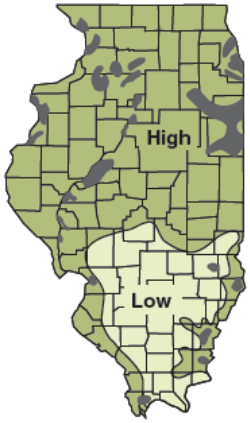


Figure 8.7. Cation-exchange capacity of Illinois soils. The darkest areas are sands with low capacity.

test levels do not build up as expected. Under the following conditions, an annual application approach (rather than buildup and maintenance) should be used:

- Soils for which past records indicate that soil test K does not increase when buildup applications are applied.
- Sandy soils that do not have a capacity large enough to hold adequate amounts of K.

Annual applications. When one of these conditions exists, or the land's expected tenure is short or unknown, continued monitoring of the level of K through soil testing every 4 years is recommended, along with the following:

- If soil test levels are below the desired buildup goal, multiply the maintenance value (K content in the harvested portion of the expected yield calculated from **Table 8.6**) by 1.5 and apply that rate annually.
- If levels are within the maintenance range, or only slightly below desired buildup levels (buildup and maintenance are less than 1.5 times removal), apply K maintenance amounts for the expected yield (**Table 8.6**).

There are advantages and disadvantages to buildup plus maintenance vs. annual application. In the short run, the annual option will likely be less costly. In the long run, the buildup approach may be more economical. In years of high income, tax benefits may be obtained by applying high rates of fertilizer. Also, in periods of low fertilizer prices, the soil can be built to higher levels that in essence

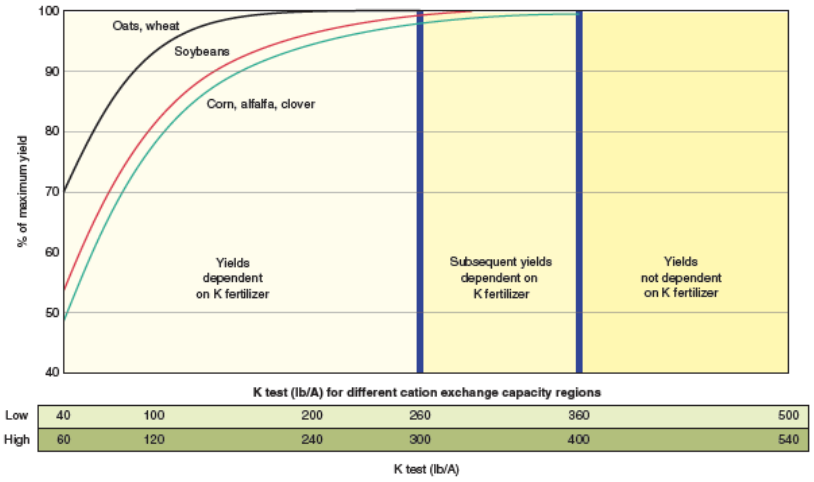


Figure 8.8. Relationship between expected yield and soil K, measured by the ammonium acetate or Mehlich-3 extractable K tests.

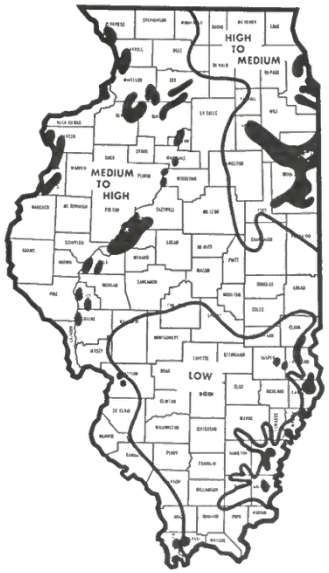
1st Agronomy Handbook 1967

Potassium

Illinois is divided into four general regions based on potassium-supplying power (Fig. 8). There are, of course, important differences among soils within these general regions because of differences in the seven factors listed below.

Inherent potassium-supplying power depends mainly on

1. The amount of clay and organic matter. This influences the exchange capacity of the soil.
2. The degree of weathering of the soil material. This affects the amount of potassium that has been leached out.
3. The kind of clay mineral.
4. Drainage and aeration. These influence K uptake.
5. pH (very high calcium and magnesium reduce K uptake).



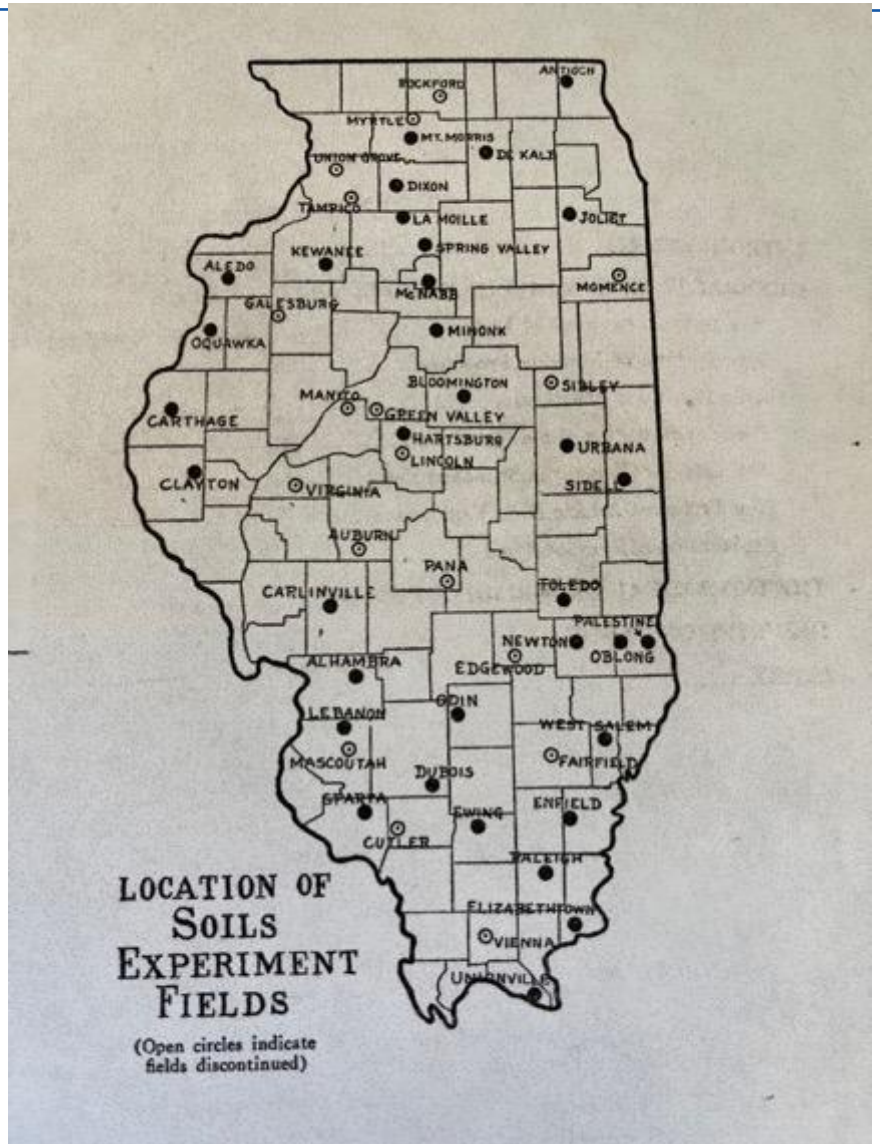
Potassium-supplying power. The black areas are sands with

Table 45. — Potassium Application Rates Based on Tests on Samples Taken Between May 1 and September 30[a]

Soil test range, lb.	Estimated percent of maximum possible yield		Potassium rates for first application to last 2 years			
			Soils low in potassium-supplying power		Soils medium to high in potassium-supplying power	
	Corn, soybeans, alfalfa, clover	Wheat, oats	K_2O, lb.	K, lb.	K_2O, lb.	K, lb.
90 or less	75 or less	90 or less	300	250	These soils are seldom this low.	
91–120	76 to 81	91 to 94	270	225		
121–150	82 to 90	95 to 98	240	200		
151–180	91 to 93	98 or more	210	175	180	150
181–210	94 to 95	98 or more	180	150	150	125
211–240	96 to 97	98 or more	150	125	120	100
241–300	98 or more	98 or more	120	100	Test every 4 years and apply enough to maintain the test.	
Above 300	98 or more	98 or more				

[a] An adjustment is suggested for samples taken earlier or later (see text).

The Illinois Experimental Fields 1926



Dixon Fertilizer Plots Established 1910

4 Sets of plots with a 4 year rotation Corn, Oat, red clover, Corn or wheat.

Static Plots for fertilizer and lime treatments.

O no fertilizer no residue

L lime

M Manure

R Residue

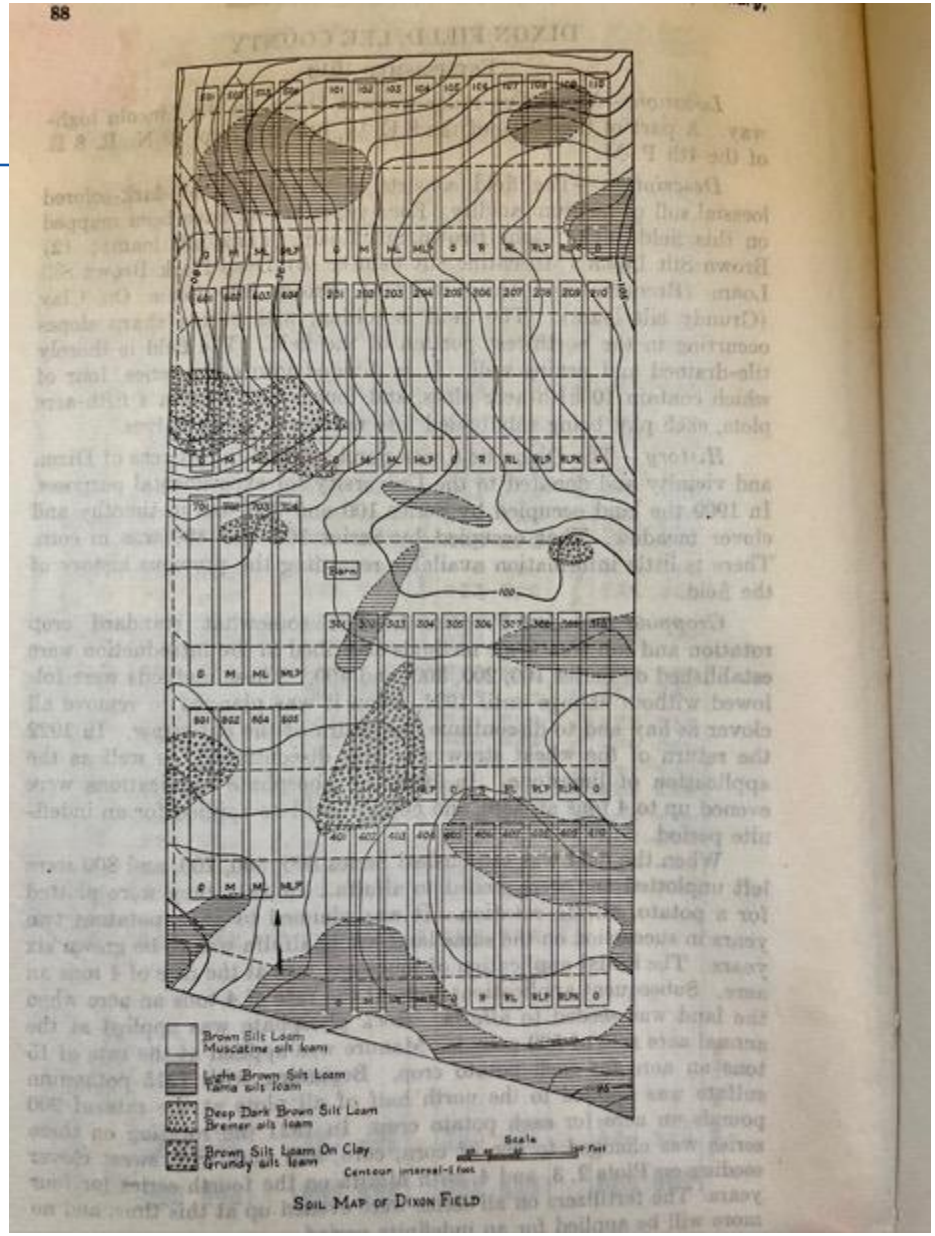
K Kanit 0-0-20 then 0-0-50

O R RL RLP RLPK Treatments for Potassium Trials

Averaged 4 years of trials to get one year of corn in each year

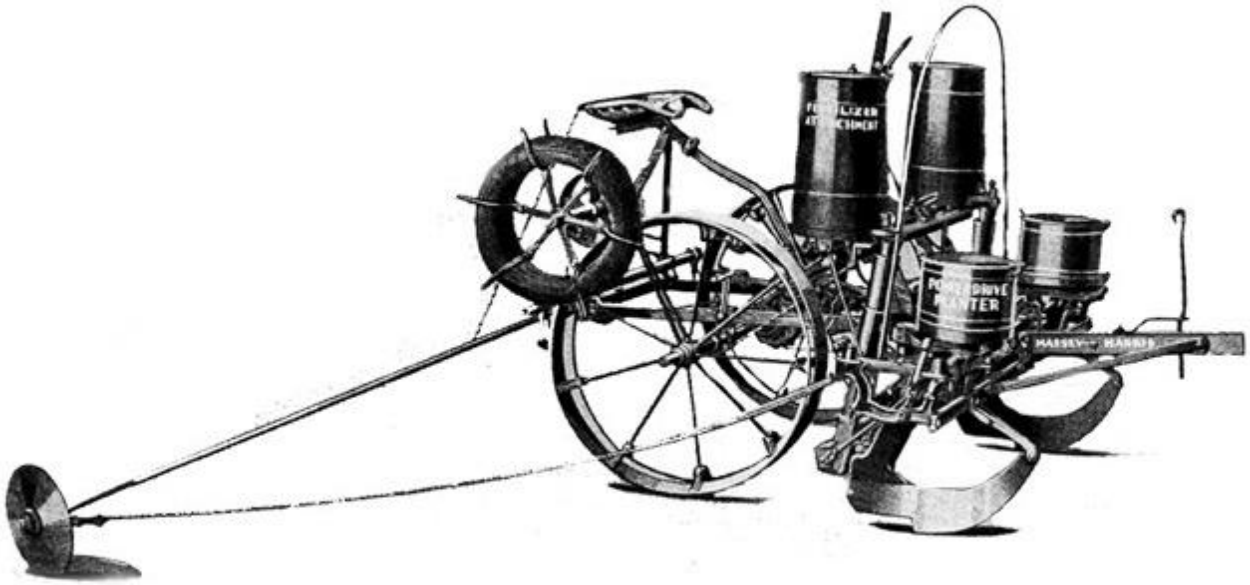
1934-1937 1938-1941

Yields from 31-86 bushels



Check Planter

Typically planted 3 or 4 seeds in hills spaced 42 inches by 42 inches apart. Fertilizer was dropped in each hill.



Plowing Corn Before Herbicides

John Deere B 1940's

Plant Population before 1950's

TABLE 4.—AVERAGE YIELDS FROM DISTANCE PLOTS IN NORTHERN ILLINOIS ON LAND PRODUCING OVER FIFTY BUSHELS PER ACRE, COMPARED WITH THOSE FROM LAND PRODUCING LESS THAN FIFTY BUSHELS

Distance between hills (inches).	Number of stalks per acre.	More than 50 bushels per acre.	Less than 50 bushels per acre.
Three kernels per hill.			
44 x 44	9720	64.2	39.9
44 x 39.6	10800	69.4	42.2
39.6 x 39.6 36 x 44	12000	69.4	42.9
33 x 44 36 x 39.6	13200	67.7	43 9
36 x 36 33 x 39.6	14520	68.4	42.2
33 x 36	15840	70.1	42.6
33 x 33	17280	70:1	43.3

- Roger H. Bray 1889-1973 was a prominent soil scientist at the University of Illinois, best known for his significant contributions to soil fertility and plant nutrition. His life's work at the university centered on practical and theoretical advancements in soil management

Soil Science 1945

SOIL-PLANT RELATIONS: I. THE QUANTITATIVE RELATION OF EXCHANGEABLE POTASSIUM TO CROP YIELDS AND TO CROP RESPONSE TO POTASH ADDITIONS[1]

ROGER H. BRAY

Illinois Agricultural Experiment Station

Received for publication June 10, 1944

SOIL-PLANT RELATIONS: II. BALANCED FERTILIZER USE THROUGH SOIL TESTS FOR POTASSIUM AND PHOSPHORU [1]

ROGER H. BRAY[2]

Illinois Agricultural Experiment Station

Received for publication March 9, 1945

Modern Fertilizer Recommendatoins

Current Agronomy Handbook Recs

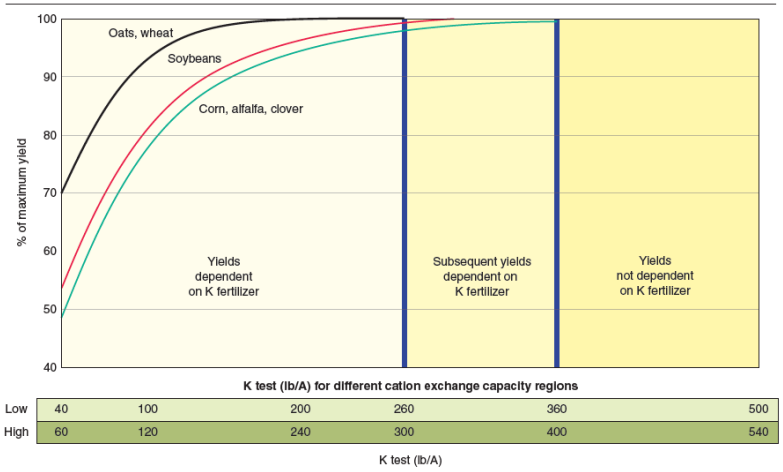


Figure 8.8. Relationship between expected yield and soil K, measured by the ammonium acetate or Mehlich-3 extractable K tests.

Roger Bray's 1930's Data

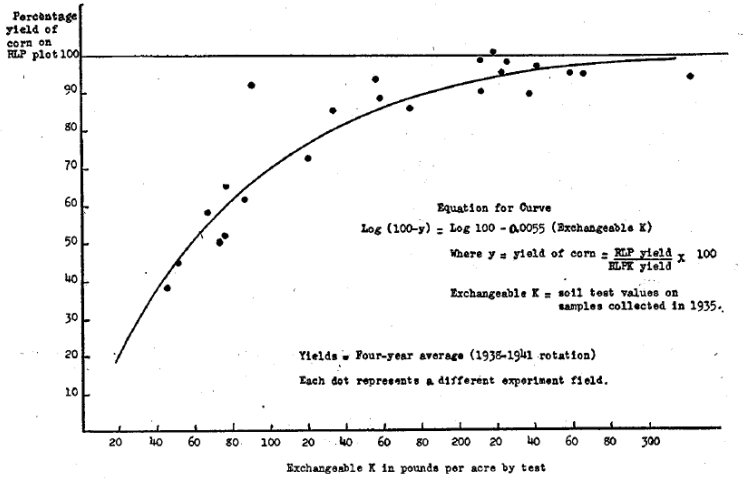
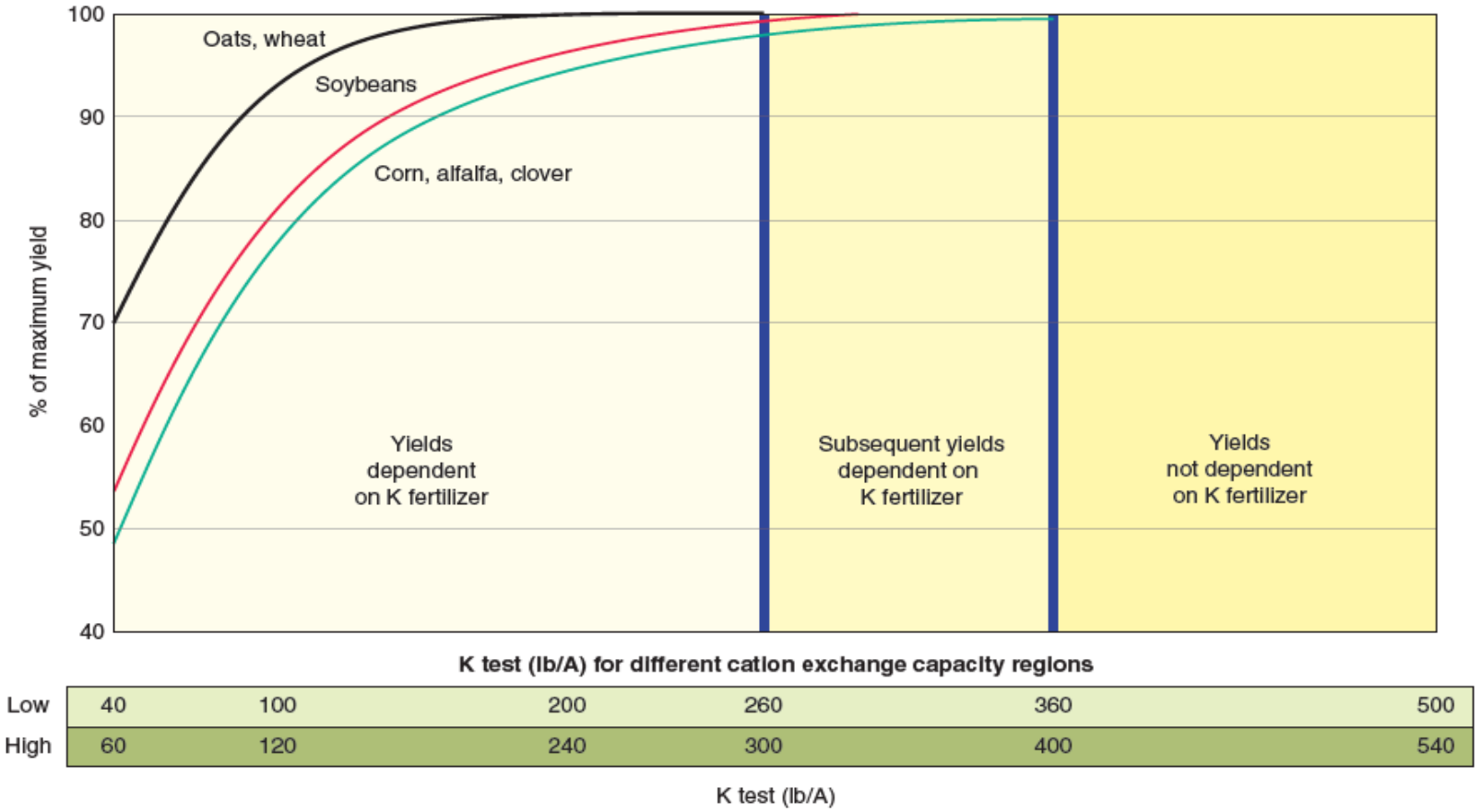


FIG. 2. RELATIONSHIP BETWEEN EXCHANGEABLE POTASSIUM AND CORN YIELDS ON UNTREATED PLOTS RECEIVING NO K_2O



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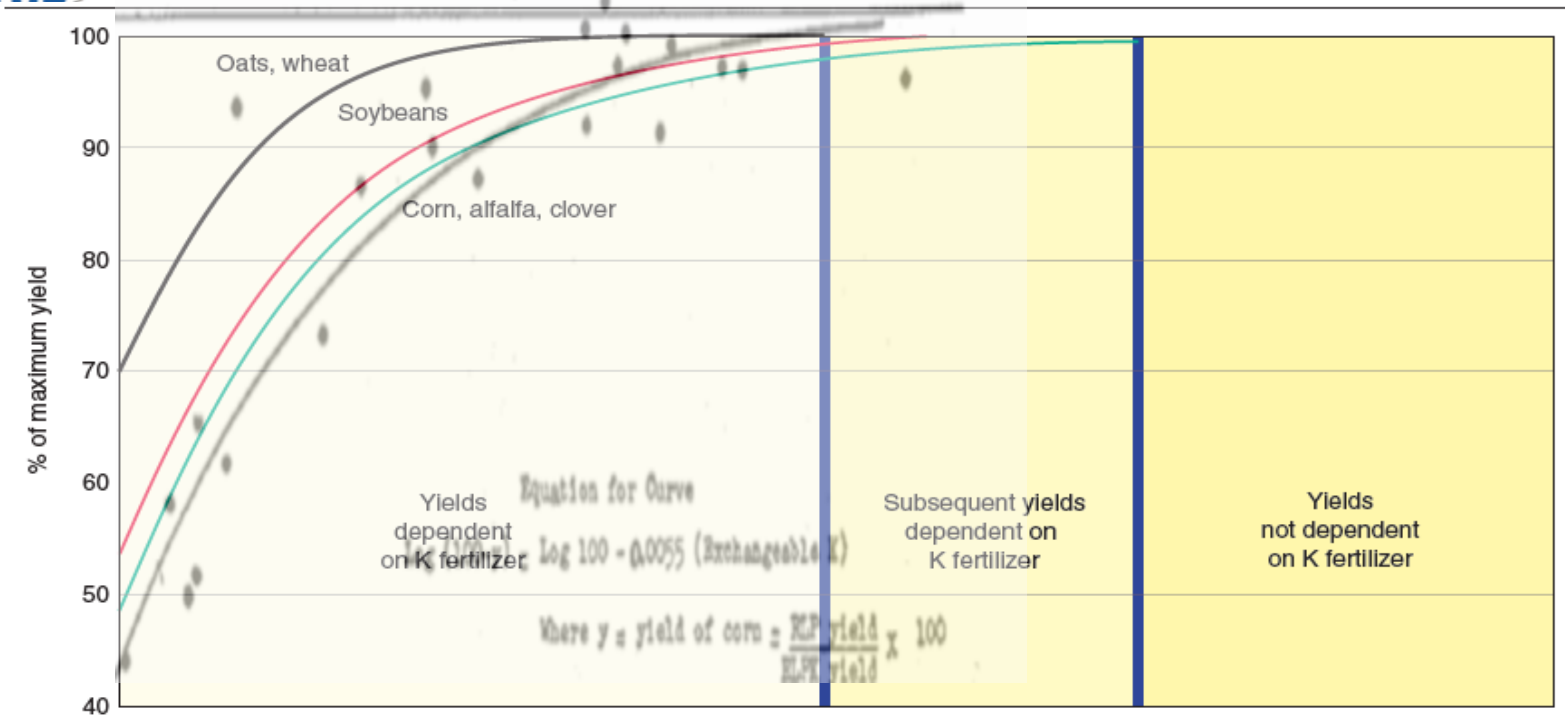


Figure 8.8. Relationship between expected yield and soil K, measured by the ammonium acetate or Mehlich-3 extractable K tests.

“What “conditions” are most important in soil test calibration? “Bray

Is it?

- Soils
- Climate
- Rotation
- Tillage
- Population
- Cover Crops

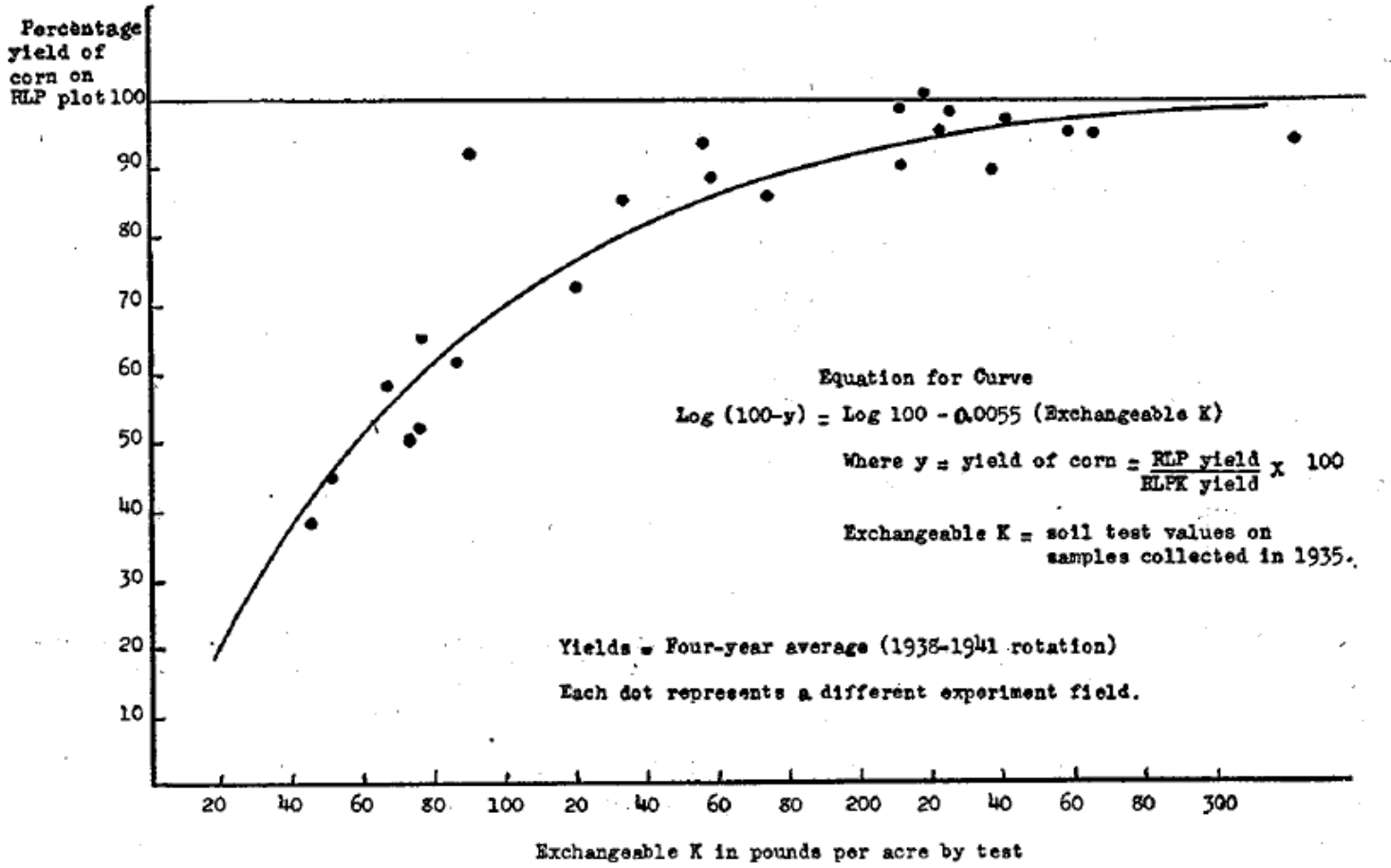
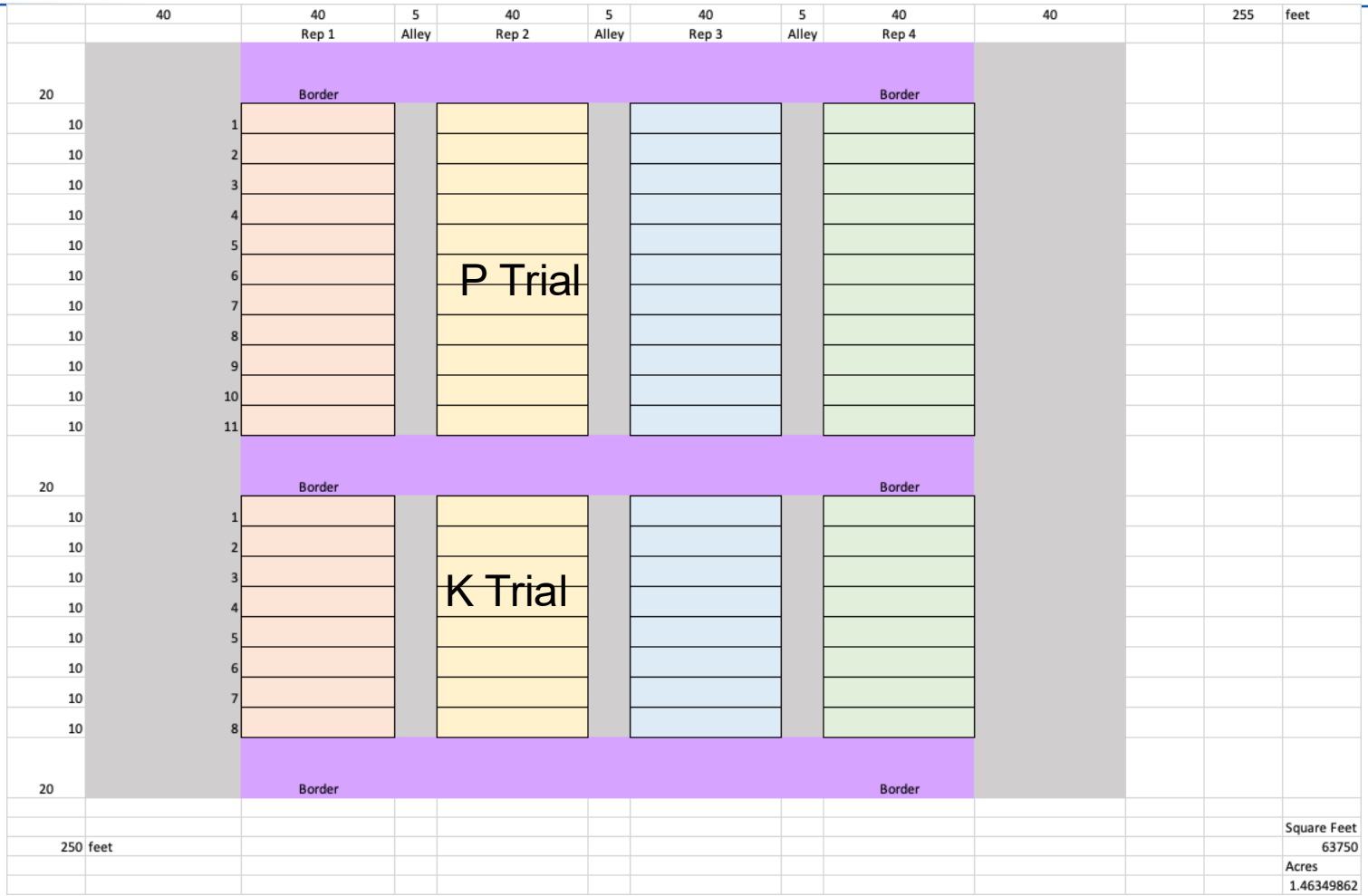


FIG. 2. RELATIONSHIP BETWEEN EXCHANGEABLE POTASSIUM AND CORN YIELDS ON UNTREATED PLOTS RECEIVING NO K_2O

K Trial to determine response to fertilizer 2022

Example plot layout for a K_2O calibration study. Rep 1 treatments were not randomized to provide clarity of treatments.

Rep 1 Trt 1 0 lb K 0 lb P	Rep 1 Trt 2 0 lb K 325 lb TSP	Rep 1 Trt 3 40 lb KCl 325 lb TSP	Rep 1 Trt 4 85 lb KCl 325 lb TSP	Rep 1 Trt 5 125 lb KCl 325 lb TSP	Rep 1 Trt 6 165 lb KCl 325 lb TSP	Rep 1 Trt 7 210 lb KCl 325 lb TSP	Rep 1 Trt 8 250 lb KCl 325 lb TSP
Rep 2 Trt 2 0 lb K 325 lb TSP	Rep 2 Trt 6 165 lb KCl 325 lb TSP	Rep 2 Trt 7 210 lb KCl 325 lb TSP	Rep 2 Trt 8 250 lb KCl 325 lb TSP	Rep 2 Trt 5 125 KCl 325 TSP	Rep 2 Trt 4 85 lb KCl 325 lb TSP	Rep 2 Trt 3 40 lb KCl 325 lb TSP	Rep 2 Trt 1 0 lb K 0 lb P
Rep 3 Trt 6 165 lb KCl 325 lb TSP	Rep 3 Trt 1 0 lb K 0 lb P	Rep 3 Trt 8 250 lb KCl 325 lb TSP	Rep 3 Trt 5 125 lb KCl 325 lb TSP	Rep 3 Trt 4 85 lb KCl 325 lb TSP	Rep 3 Trt 2 0 lb K 325 lb TSP	Rep 3 Trt 3 40 lb KCl 325 lb TSP	Rep 3 Trt 7 210 lb KCl 325 lb TSP
Rep 4 Trt 7 210 lb KCl 325 lb TSP	Rep 4 Trt 3 40 lb KCl 325 lb TSP	Rep 4 Trt 4 85 lb KCl 325 lb TSP	Rep 4 Trt 1 0 lb K 0 lb P	Rep 4 Trt 6 165 lb KCl 325 lb TSP	Rep 4 Trt 2 0 lb K 325 lb TSP	Rep 4 Trt 5 125 lb KCl 325 lb TSP	Rep 4 Trt 8 250 lb KCl 325 lb TSP


40
40
Rep 1
5
Alley
40
Rep 2
5
Alley
40
Rep 3
5
Alley
40
Rep 4
40
255
feet
Border
Border
P Trial
Border
Border
K Trial
Border
Border
20
10
1
2
3
4
5
6
7
8
9
10
11
250 feet
Square Feet
63750
Acres
1.46349862

20 and 21 century developments

1909	Fritz Haber synthesized ammonia from nitrogen and hydrogen gas
1913	Carl Bosch performed Haber's ammonia synthesis on an industrial scale
1947	it was reported that many lakes in the US and Europe were undergoing eutrophication
1950s	through the mid-1950s, N additions to coastal ecosystems were incorrectly considered a benefit to productivity
1960s	there existed 9 reported 'dead zones' in coastal areas
1970s	on a global scale, the rate of Nr creation by the Haber–Bosch process surpassed natural N fixation
1985	stratospheric ozone depletion was discovered by scientists from the British Antarctic Survey
1989	John Aber et al. demonstrated that excess N deposition to forests not only causes damage the forest, but it can also make forests a net source of N
2009	Ravishankara et al. discovered that N2O emissions are currently the most important ozone-depleting substance
2011	there are 540 reported dead zones on a global basis
2022	Time to update calibration studies and testing equipment

Questions?


RADICLE
AGRONOMICS