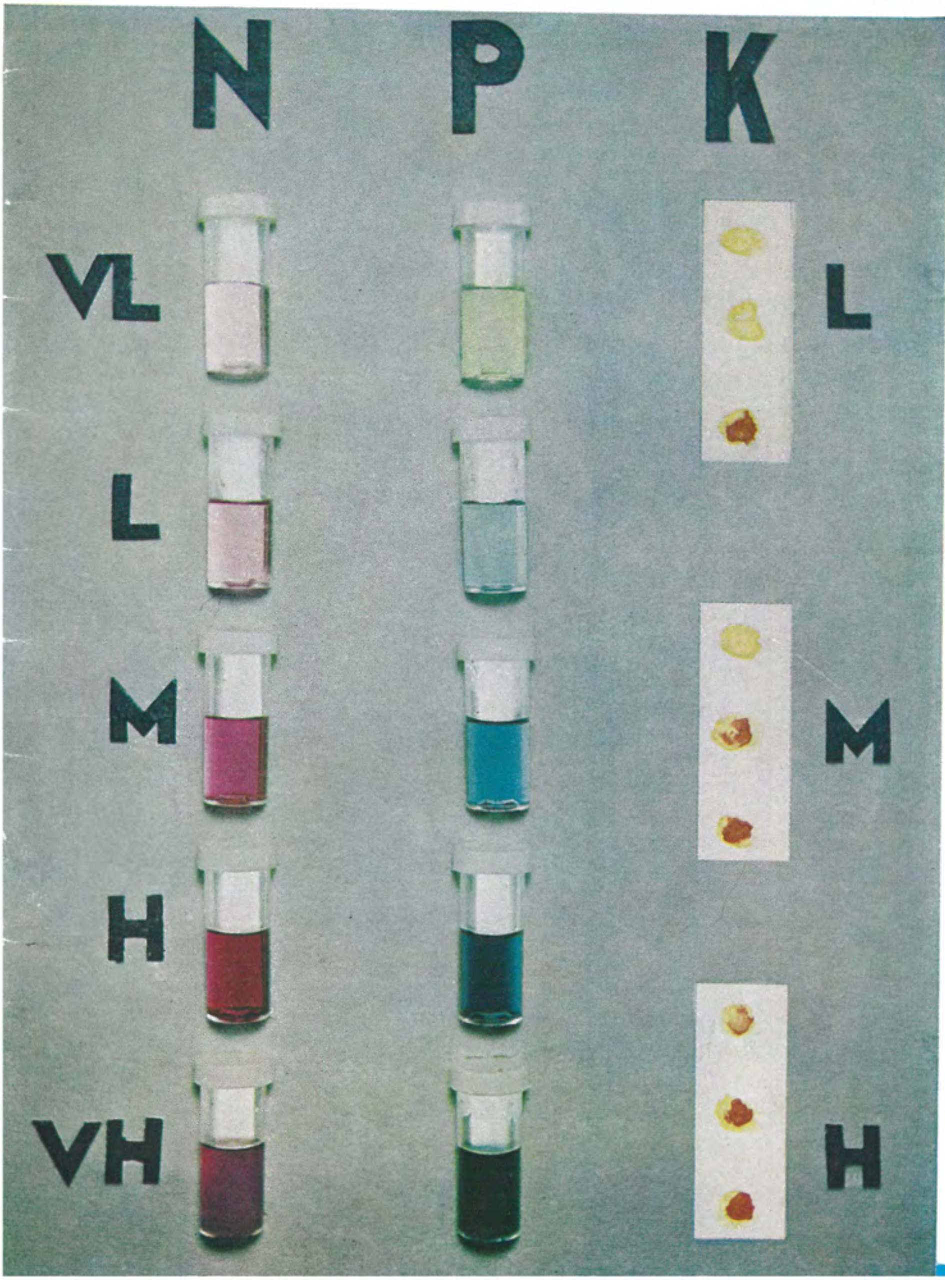
Better Crops

WITH PLANT FOOD

May-June, 1964

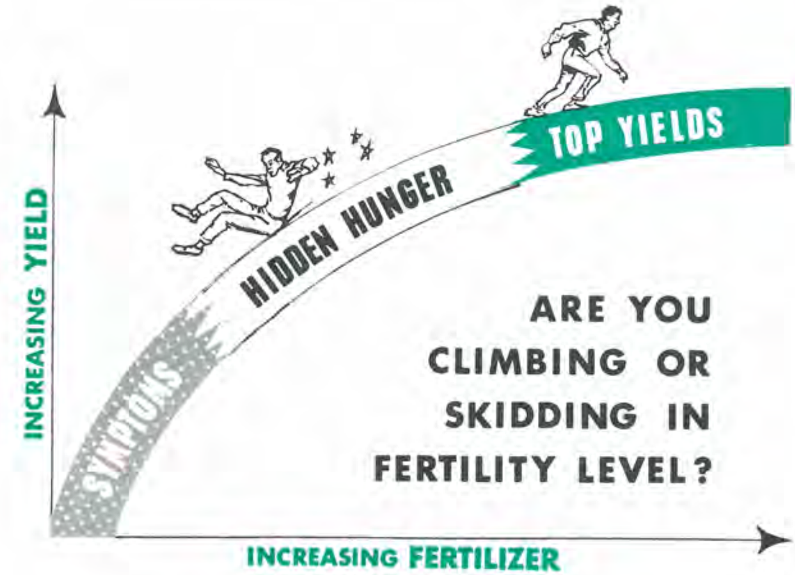
20 Cents



Fight HIDDEN Hunger With Chemistry

A SPECIAL ISSUE

ON . . .



Fight HIDDEN Hunger

AN INTRODUCTION

Are you climbing UP or skidding DOWN in available nutrients now known to be essential for crop growth?

Detecting "hidden hunger" in crops is a growing problem as yields and yield goals rise. In the hidden hunger zone, with no symptoms to guide us, we must turn to more diagnostic chemistry (or careful guessing) to estimate requirements for fertilizers and lime to produce most economical yields.

How can you know that each necessary nutrient is available in adequate amounts for maximum economic yields?

Our conditions are more complicated than when I started working on soil fertility problems more than 40 years ago in Indiana. Soil experimental fields then were designed to find how to start a soil improvement program on each of many soil types. Today we still have variable soil types PLUS man-made variables *within* soil types PLUS varying levels of management.

WHAT IS HIDDEN HUNGER?

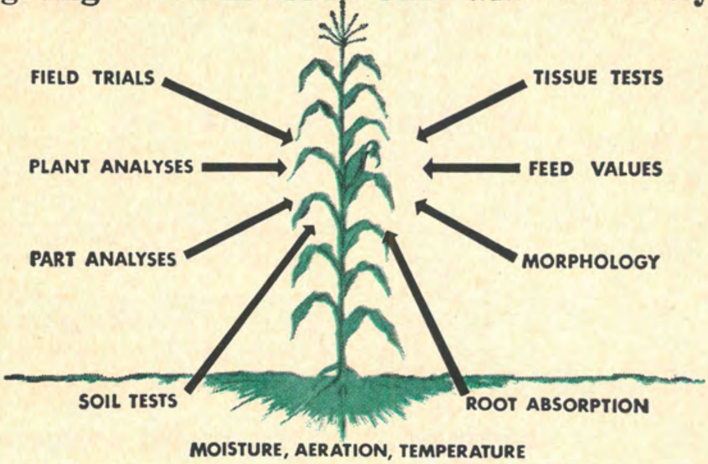
The hidden hunger zone is the area on a yield curve where no

Many diagnostic tools are available . . .

. . . to predict probable nutrient needs.

. . . to diagnose less-than-optimum nutrient conditions—including hidden hunger.

Fighting HIDDEN HUNGER with Chemistry



BY HERBERT L. GARRARD

. . . with CHEMISTRY

. . . and learn to think like a plant as well as a chemist.

definite symptoms are observed, but where profitable increases to a nutrient are expected.

The top of this section would be the spot where the last unit of a nutrient applied would just pay for itself. This yield level would then give the greatest net return per acre from the total investment in that nutrient. This yield will be slightly below the physiological optimum, or the 100 per cent of yield possible.

SMALL DIFFERENCES ARE HARD TO MEASURE

When there is a great deficiency of any nutrient, the question is how much to apply? What is the *last* unit to buy? The first unit applied may return several dollars per $1 invested. When do we stop?

If tests indicate a "high" supply of a nutrient, but you know it is being depleted, when do you *begin* to use a small amount of this nutrient as a starter, for maintenance, for insurance?

The answers to such questions demand very accurate experimental work, plus chemical guidance (and some guessing on the liberal side), if you expect to get maximum economic yields.

Small but profitable yield differences are difficult to measure with the most accurate technics. Most careful experimenters feel lucky if they can measure accurately differences of 2 to 3 bushels of corn per acre.

EVEN SMALL INCREASES PAY COSTS

Only \$1, or about one bushel of corn, would buy:
about 20-25 lbs. K_2O (17-21 lbs. K)
about 10-12 lbs. P_2O_5 (4.4-5.3 lbs. P)
about 8-12 lbs. N.

What is the *last* \$1 to invest in each of these nutrients? When should we make small investments in micronutrients? You can see that some chemical aids will be helpful in making these decisions, and especially in the hidden hunger zone.

YOUR PLANT IS FINAL JUDGE OF AVAILABILITY

The plant itself is the final judge of what is or is not available, of what is a deficiency or an excess of each nutrient. The plant integrates all factors in the environment to arrive at the final product.

Actual field trials answer whether a crop will respond to additional nutrients at a specific location. But because of unknown limiting factors, simple field trials alone do not always explain why top yields are lower than the expected or potential yield.

Pot trials may indicate what to expect under field conditions but do not always correspond to field responses. Such discrepancies usually must be explained by chemistry or supplementary facts.

FIELD TRIALS COME FIRST IN DIAGNOSTIC APPROACH

Field experiments are a must for calibrating any diagnostic test. In calibrating soil tests, field trials must establish what conditions in the soil are optimum for best growth. Likewise, plants from optimum yield experiments must be available for calibrating plant tests.

A major problem in field experiments has been limiting factors holding down yields and failure to cover the full response range.

As yield goals climb, soil and plant tests should be recalibrated from actual experiments at these high yield levels. When new crop varieties with higher yield potentials appear, our diagnostic tests should be rechecked against these new varieties grown at high fertility levels. Crop varieties differ in their demands for major and micronutrients.

In field trials to determine individual effects of more than one nutrient, the subtractive system of comparisons *must be used*.

For example, when determining the needs of corn for N, P and K,

Experiments must be agronomically logical before it is worthwhile worrying about the statistical significance of the data.

the NPK combined treatment must be the "check" plot with which to compare PK, NK and NP treatments. Of course, a no treatment (O) plot should be included.

If we use single treatments or an additive comparison—such as O, N, NP, NPK—we may draw wholly erroneous conclusions.

• GET BACKGROUND FACTS FOR RIGHT INTERPRETATION

After you get the few chemical facts indicated by soil and plant tests, don't forget all the *background information* known or needed as a basis for a logical interpretation. The trend is swinging back to *more* background data on soil test information sheets to improve the individual interpretations.

Recommendations for *maximum economic yields rather than average* yields is the first requirement. Needs may differ due to variety, planting rate, fertilizer application methods, as well as root environment factors due to physical conditions.

• THEN PUT YOURSELF IN THE PLANT'S PLACE

Before daring to compare results of soil tests with various plant tests, you must learn to think like a plant as well as an analytical chemist.

Plants must live under conditions allotted by the grower. They are not free to move to a better location. And they cannot go to town to balance their diet.

Just what is nutrient *unbalance*? Have you ever eaten strawberry shortcake? The first two or three helpings taste mighty good. But if you had nothing but strawberry shortcake for many days, you might like to trade strawberries for some steak and vegetables. So, nutrient unbalance of plants may mean that plants are gorged with certain important nutrients while starving for other nutrients.

• PLANT vs SOIL TESTS—WHY?

Results of tissue tests or leaf analyses may not always agree with soil test indications. Why? It is logical from the plant physiology standpoint. If one nutrient is low enough in availability to stunt growth even temporarily, then there may be a build-up of other nutrients in the sap or tissues.

So soil tests and plant tests usually would agree on the greatest limiting factor, but they might not agree on relative availabilities of other nutrients.

For example, if N shortage stunts plants, P and K might build up in the sap, even though soil tests indicated deficiencies of these nutrients. When K is relatively the lowest in corn, you may expect high

Crop species vary considerably in their abilities to extract needed nutrients from a soil.

concentrations of unused N and P in the sap. If P starvation stunts crops, then N and K concentrations in the plants may seem to have little relation to soil test indications.

• DON'T FORGET THE COMPETITION BETWEEN CATIONS

There is usually an *inverse relationship* in concentrations among K, Ca, and Mg in a plant.

When very high concentrations of any two of these cations surround roots, the third element has difficulty getting into the plant. Such relationships show up constantly in leaf analyses.

On high-lime soil, corn often shows severe K hunger. Under the same conditions, sweet clover will grow relatively better without added K, apparently due to its tolerance for high Ca.

This fact stresses that species vary considerably in abilities to extract needed nutrients from a soil.

• AND THE NEED FOR MORE MORPHOLOGY STUDIES

In severe nutrient deficiencies, external and internal plant parts often are plainly abnormal.

1 Most low-N PLANTS are light green (less chlorophyll), stunted, and slender.

2 Most low-P PLANTS are short and slow to mature because cell division is retarded.

3 K-starved CORN shows several structural differences—short internodes, darkened nodes, less roots including brace roots, early breakdown of internal tissues of lower stalk, chaffy kernels on small ears, etc.

4 K-hungry WHEAT or BARLEY lodges because of weak stems.

5 K-starved TOMATOES drop fruits early because of abnormal stems.

6 K-starved PEACHES decay sooner, accompanied by higher respiration.

Many more morphological studies are needed to explain relations between nutrition and plant development.

• QUALITY IS MORE THAN MEETS THE EYE

Quality standards of some products at the market place, based largely on eye-ball tests, often are as undescribable and unmeasureable as the blush of a bride. There may be unseen qualities of more importance—qualities that could be specified by chemical or physical tests, that may be related to nutrient deficiencies.

More products may be grown on contract in the future, where the contractor will cooperate with the grower to insure a product of desired quality.

Feed values of crops must be determined by actual feeding trials with animals. Yet, various chemical and biological tests can estimate feed values—and help improve livestock menus.

"Hidden hunger" can affect livestock nutrition also. In some states, feed stuff testing services (similar to soil testing) help farmers decide on feed values by other than the "eye-ball test."

Quality in feedstuffs depends not only on the protein and energy values, but also on the palatability and the actual intake by the animal.

• IT'S THE *MAN* IN MANAGEMENT THAT COUNTS

No one diagnostic tool, standing alone, is infallible. But if all available tools are used together, to check one against the other, they improve your chances of drawing the right conclusions, making the right recommendations, and doing all the right things at the right time.

In the hidden hunger zone, careful attention must be given to all controllable factors. Your timing is most important. Plan a long-time fertility program.

The End

With fertility for only 110 bushels & management for 150, there may be 40 "Hidden Hunger bushels"—extra dollars waiting to step out of your soil.

Ask The SOIL

J. F. REED AND W. L. NELSON

Properly calibrated chemical soil tests are valuable for predicting fertility needs.

In these tests we expect a chemical extractant, in contact with the soil for a few minutes, to extract nutrients proportional to the amount available to plants during their growing period.

Confidence in soil tests must be maintained. Yet, we must avoid creating the impression that soil tests and the resulting fertilizer recommendations are "miracle workers." The soil test is a helpful diagnostic tool just like the thermometer or the stethoscope for the doctor. But all such tools require skill plus common sense in their use and interpretation—plus a realistic approach to the needs and goals of the growers.

To use soil tests most effectively in fighting Hidden Hunger, many points must be recognized:

• KEEP RESEARCH UP TO DATE IN HIGH YIELD AGE

The object is to determine the plant nutrient level for continuous top economic yields. Field and greenhouse experiments are constantly conducted to calibrate or standardize soil tests. But many field studies

HIGH-YIELD FIELD TRIALS liks this are necessary to calibrate soil tests. To test response to a plant nutrient, all other controllable limiting factors should be eliminated. A field test for P or K response, when N may become limiting, is wholly misleading.

are already out of date because out-moded practices were used and limiting factors were not eliminated.

For example, *soil tests calibrated for 110 bushels of corn per acre, when farmers are interested in 150 bushels, are behind times.*

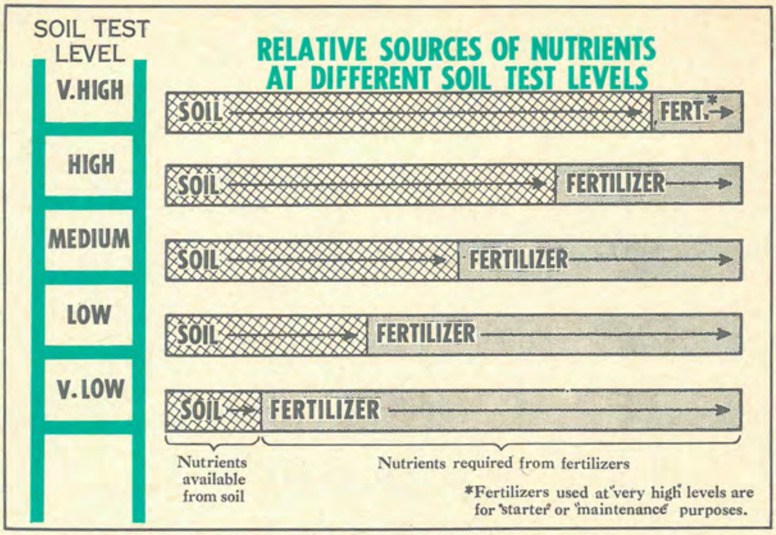
A "limiting factor" is something that prevents top performance. In a car it may be a spark plug or an unbalanced wheel. In an experiment it may be unadapted variety, pests, plant spacing, improper fertilizer placement, water control, or one of many things.

Limiting factors may cut response to fertilizers to half or less of what it could be. When this happens, the researcher fails to measure what he set out to study.

• TIME OF SAMPLING CAN BE IMPORTANT

Should more samples be taken under the growing crop—during its stress period, the time of greatest drawdown, and in the fall? Illinois work shows that on some soils the amount of available K drops markedly during the summer.

Most samples are now well taken, but emphasis on good samples



AS THE SOIL TESTS HIGHER in a plant nutrient, the amount needed from fertilizers becomes less. But even at high levels, some nutrients come from fertilizers—to maintain fertility and provide insurance.

must be continued. The trend is toward more and more of the samples being taken by trained soil samplers.

• LABORATORY METHODS INCREASE ACCURACY

Improved laboratory equipment, techniques, and methods have been a great help to soil testing. The use of flame photometers, better pH meters, and newer methods have increased the accuracy of laboratory determinations. Laboratories must run check samples periodically to be sure the apparatus and solutions are OK.

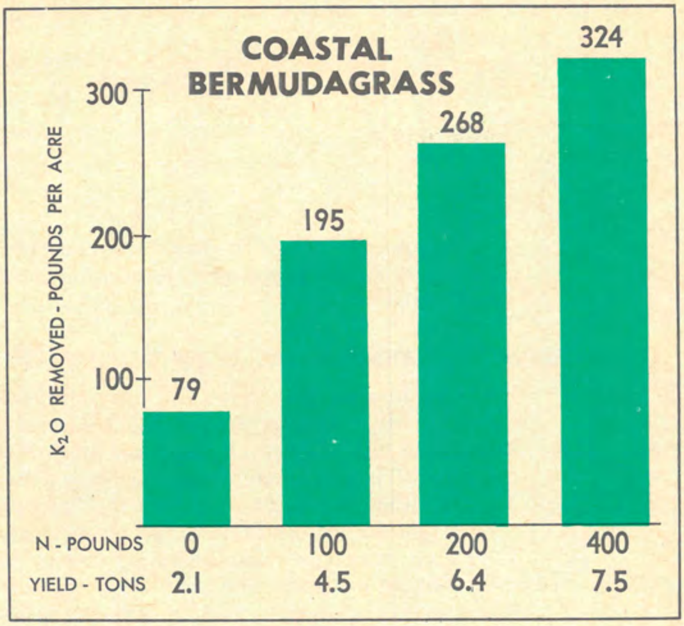
To better approximate growing conditions in the field, Iowa State University does not allow soils to dry before testing. This is very important for nitrogen and potassium and may be true for other elements. When allowed to dry, some soils samples increased potassium test levels more than twice what they should be. In Missouri, ammonia in some soils has caused potassium to test too high with the sodium cobaltinitrite method.

• INTERPRETING SOIL TESTS: THE PAY-OFF

The pay-off comes when the soil test is used, along with other background information, to assist in making a recommendation.

E. J. Kamprath and J. W. Fitts say of soil tests:

"The chances of getting a profitable response to fertilization are much greater on a soil that tests low in a given nutrient than on one that tests high. This does not rule out the possibility of a profitable response from fertilizer application at a high level of fertility, if yield factors other than fertility are optimum. Likewise, a profitable response on soils of low fertility is not assured when other factors such as climate and management are poor.



AS NITROGEN BOOSTS grass yields, potash *removal* goes up, soon depleting your soil. Failure to apply a plant nutrient because the level is "high" is like adding no gas to your car on a long trip because the gas gauge showed "full" when you started.

"Interpretation of soil test results and recommendations becomes a question of how to improve the fertility status of the soil. How much will be needed to change the soil from low to medium or high in that element? . . . What will be the most economical level at which to maintain the nutrient status of the soil?"

Studies on 80 central Indiana farms show the fertility level in the highest yielding one-fourth and lowest yielding one-fourth of the fields.

	CORN		SOYBEANS	
	High 1/4	**Low 1/4**	**High 1/4**	**Low 1/4**
1961 yield (bu.)	117	75	38	24
P_2O_5 test (lbs.)	359	258	381	215
K_2O test (lbs.)	237	185	210	172
ph	6.2	6.2	6.3	6.2

(Purdue Mimeo EC–260).

Data from North Carolina show the importance of the P fertility level:

P added lbs./A	**Low P** Yields of seed cotton lbs./A	**High P** Yields of seed cotton lbs./A
0	834	2112
22	1403	2287

The highest yields were obtained where there was a high P level. Adding P increased the yield on the low level soil, but this amount did not bring it up to the yield obtained at the high level.

An average of five North Dakota trials with early planted barley on high-K soils showed the following (30 lbs. of N and 18 lbs. of P applied):

lbs. K/A	Yield bu./A
0	44.8
12.5	48.3
25	49.2

These facts highlight a major point: *where other factors are favorable, a profitable response to fertilization may be obtained even at the high level.*

BASIC QUESTION: WHAT DOES THE FARMER WANT?

Most farmers who have soil samples tested are in the upper 25 percent. They expect recommendations for better yields. Some interpreters use soil tests to see how much fertilizer can profitably be applied. Others use soil tests to see how little fertilizer the farmer can get by with. Ten years from now the "average" farmer of today will no longer be on the farm unless he is simply waiting for retirement.

Hence, tomorrow's farmer should receive fertilizer recommendations for the top economic yield. At the same time, a soil test gives good opportunity for making needed suggestions on crop management other than fertilizer and lime.

MAKING RECOMMENDATIONS—NOW DONE BY MANY

At one time recommendations from soil tests were made only by highly trained technical men who also ran the chemical tests. Now, many other groups make these recommendations after receiving special training.

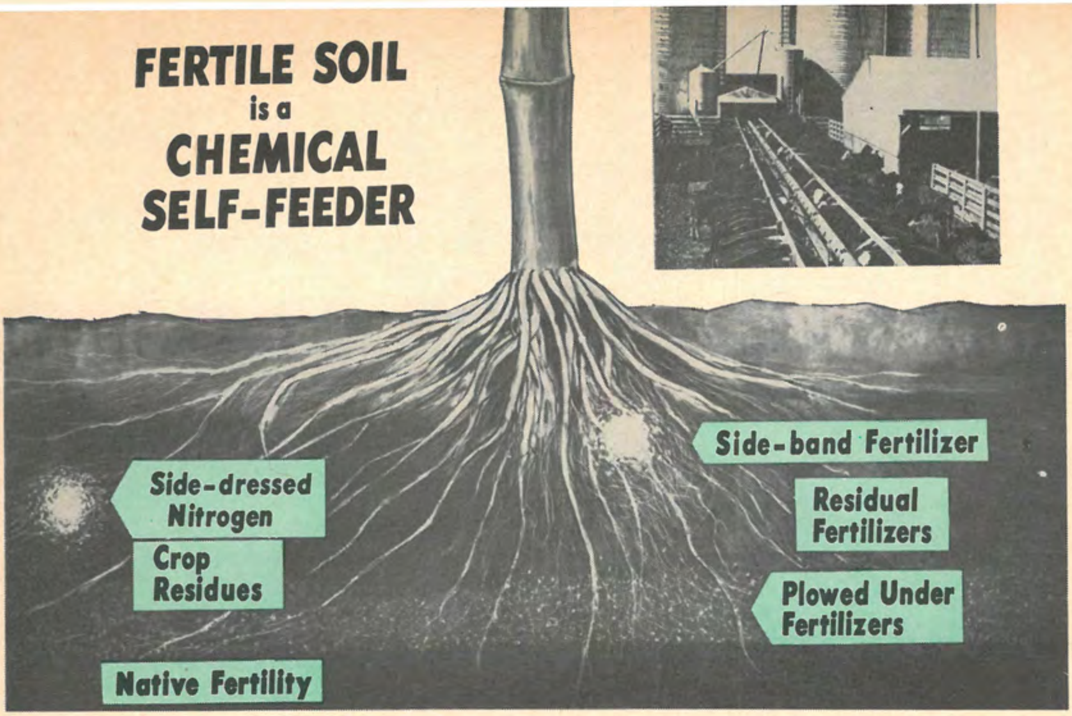
This is a good practice. It brings recommendations from a man with first-hand knowledge of the farmer and his problems—a man who can follow up on results obtained.

We sometimes tend to ascribe a degree of accuracy to the soil test values that was never intended. The most "accurate" data are merely relative and usually must be interpreted back into general terms. A certain number of pounds of available P or K may be "high," "medium," or "low," depending on the crop requirements or on other soil conditions.

For example, a given test for P might be "high" for corn but "low" for potatoes. A certain number of pounds of available K may be adequate under ideal conditions—but if aeration and root growth are restricted, as in a wet, cool, or compact soil, K might be inadequate.

RECOMMENDATIONS WHEN LEVELS ARE HIGH

One might ask, "If my soil tests high in a plant nutrient, should I add more?" This depends on what is meant by "high." If it means very high, that there is a great abundance of the element present in the available state, then it might be well to leave it off. But currently this is a rare situation.



WHAT DOES THE CROP NEED? This question faces the farmer who seeks to know WHAT, WHEN, and HOW to apply plant nutrients most profitably. The modern farmer is growing more efficiency conscious—looking carefully at labor saving methods, costs, and operational conveniences. This extends to fertilizer application and other services offered by the fertilizer industry.

Most laboratories assign the value "high" not to such very high conditions but to a level at which the odds point to little or no response to applications of that nutrient that year. At the same time, failure to apply any of this nutrient will surely result in a depletion of that plant food. Also, under some environmental conditions crops will respond profitably to a nutrient even with a high test, as mentioned earlier.

Often farmers fail to place a price tag on residual fertility. While immediate return on the fertilizer investment is important, the better farmers are interested in big returns over the years. In many cases, just the residual value of the fertilizer the year after application pays the original investment plus interest.

So, most laboratories and soil testers suggest adding a plant nutrient, even if the level is high, to avoid depletion of that plant food. Such depletion can occur fairly rapidly in some soils if yields are good.

For example, in Tennessee the K level in a soil dropped from "high" at the beginning to "low" at the end of one season as a result of cutting 4 to 5 tons of alfalfa hay.

Sizable quantities of nutrients are required to maintain even a medium test: (Purdue Ext. Cir. 474)

APPROXIMATE AMOUNTS OF P_2O_5 AND K_2O REQUIRED TO MAINTAIN A MEDIUM SOIL TEST

	Yield Per Acre	P_2O_5 lbs./A	K_2O lbs./A
Corn	130 bu.	50	50
Soybeans	45 bu.	40	60
Wheat	60 bu.	50	20
Hay	5 tons	60	170

• SECONDARY MICRONUTRIENTS: AN EMPHASIS

As yields go up and soil depletion increases, more emphasis must be focused on plant needs for secondary and micronutrients. This opens a relatively new soil testing field. It calls for a vigorous research program to evaluate the possibilities of using routine soil tests to determine needs for these elements.

While some research work along these lines is under way, most soil testers do not feel the point has been reached where routine laboratory tests can accurately predict needs for many micronutrients.

• LIME RECOMMENDATIONS SOMETIMES OFF—WHY?

Probably the most widely used tests are those that serve as a basis for lime recommendations. But in many instances lime amounts recommended have been inaccurate. There are many reasons for this, including quality and fineness of lime, how recently it was applied, mixing, and depth of plowing.

For example, most recommendations have been based on a 6⅔-inch plow layer. But more and more farmers are plowing 10 inches, which calls for 50% more lime. This must also be considered in P and K recommendations in a "buildup" program.

• IN SUMMARY

1 A soil test indicates the relative soil fertility level.

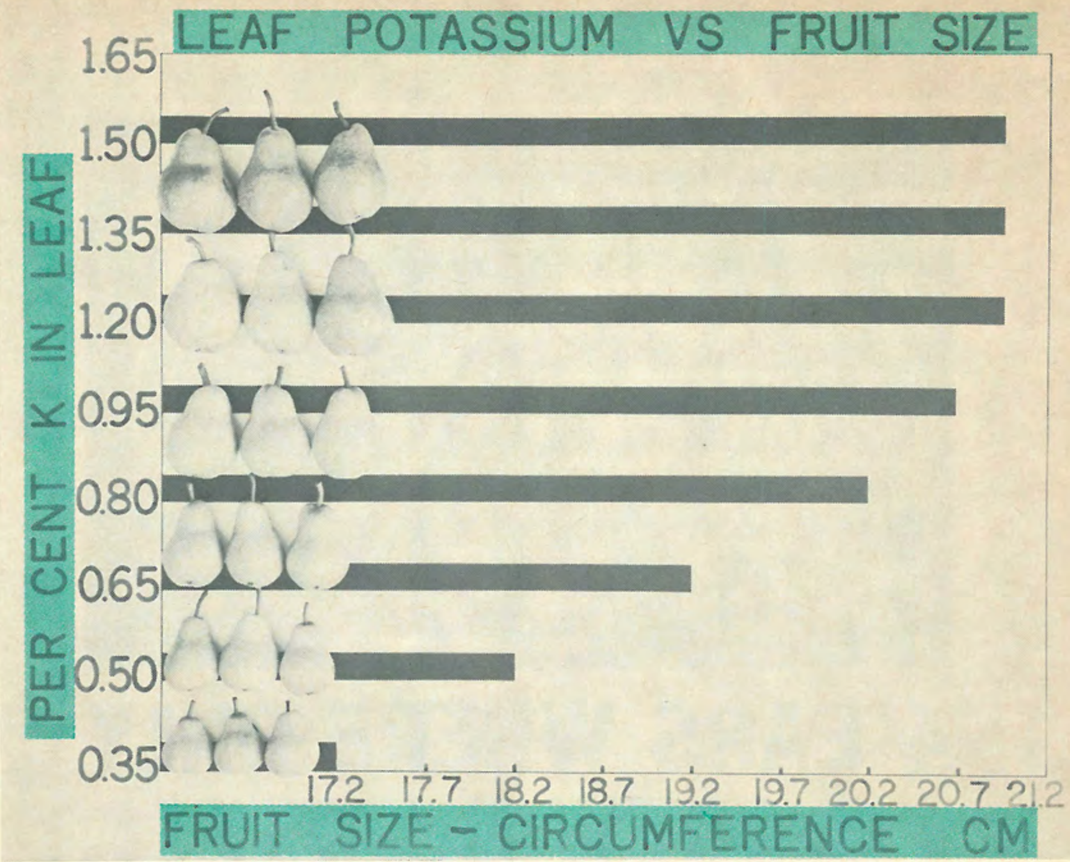
2 High yield research determines the fertility levels at which most profitable yields are consistently produced.

3 When interpreting a soil test, the goal should be to maintain the plant nutrients at that level where the supply cannot be a limiting factor at any stage from germination to maturity.

4 As we go to higher yields, exact fertilizer amount is not so important—in fact, levels should be more than adequate. *With fertility for only 110 bushels and management for 150, there may be 40 "Hidden Hunger" bushels.*

5 Soil tests are important in planning a long time fertility program. *Sampling every 3 to 5 years with integrated recommendations for the intervening years is a must.*

The End



Pears attain maximum yield of No. 1 fruit at same midseason leaf level of 1.0% K.

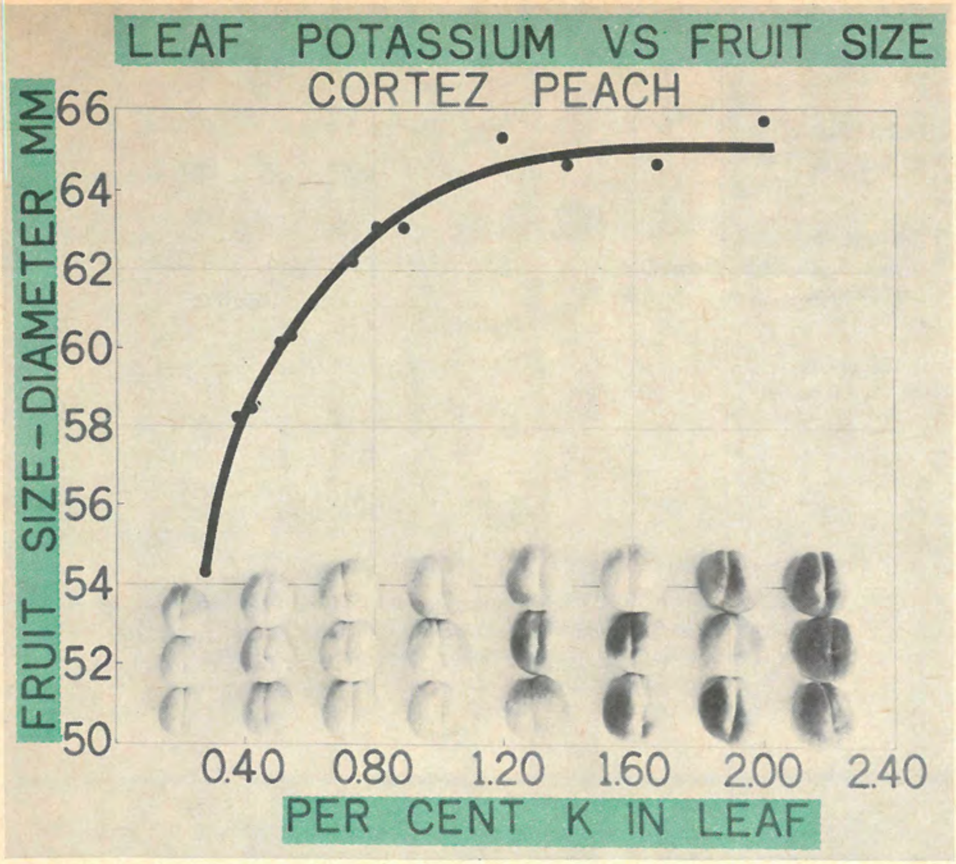
Ask The LEAF

The ultimate aim of research is to produce something of practical value. Leaf analysis has been widely accepted as a useful research tool for studying plant growth problems. Practical application of leaf analysis has been confined to a limited number of crops. But recent advances in leaf analysis research are now stimulating much more extensive use by growers.

• ADVANCES IN RESEARCH OPEN NEW DOORS

The agricultural scientist uses leaf analysis today not only in plant nutrition studies, but also as a research tool in climatic studies, soil moisture, temperature, and physical condition, as well as plant disease research.

A fast look at a few major areas of today's work shows what has happened to leaf analysis research in just 10 years. For example:



Peaches attain maximum yield of No. 1 fruit at mid-season leaf level of 1.0% K.

F. S. FULLMER AND M. E. McCOLLAM

1 We see marked advances in instrumentation—the direct reading spectrograph enabling the research worker to analyze plant material for 10 to 14 elements at once. This instrument has cut down materially the requirements of former, more time consuming procedures. One implication is a much larger volume of leaf analysis research on secondary elements and micronutrients.

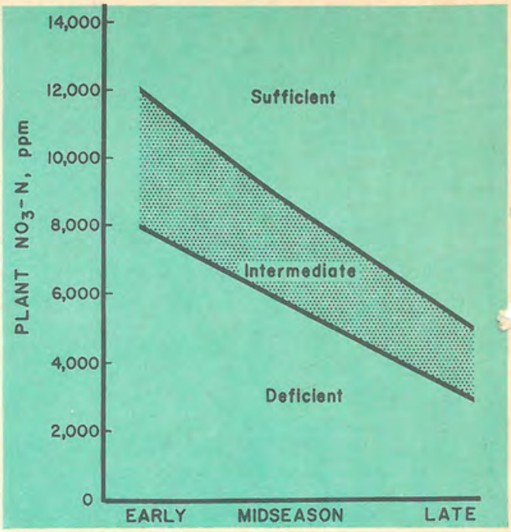
2 Research on sugar beet yield and sugar content by Albert Ulrich (Univ. of Calif.) has included a great volume of leaf analysis work—including a nitrogen control system through seasonal use of the leaf analysis procedure. This method helps guard against nitrogen excesses and deficiencies.

3 Jones and Embleton (Univ. of Calif.) utilized leaf analysis to

CLASSIFICATIONS OF NUTRIENT CONCENTRATIONS

- **Nitrate-Nitrogen**
- **Phosphate-Phosphorus**
- **Potassium**

. . . in potato petioles as related to sampling time.



POTATO GROWERS are now guided by such leaf analysis material as these classifications—showing deficient, intermediate, and sufficient ranges of leaf nutrient levels throughout the season.

Growers operating on deficient levels and in the intermediate zone are encouraged to raise the leaf levels to the sufficient zone for maxi-

show how nitrogen application to citrus trees can be more accurately controlled, avoiding N deficiencies and excesses.

4 Lilleland (Univ. of Calif.) has used leaf analysis extensively on deciduous fruit trees. This work has resulted in locating and improving areas of potassium deficiency. More recently, the potassium level of the leaf has been definitely related to improved fruit size in these areas.

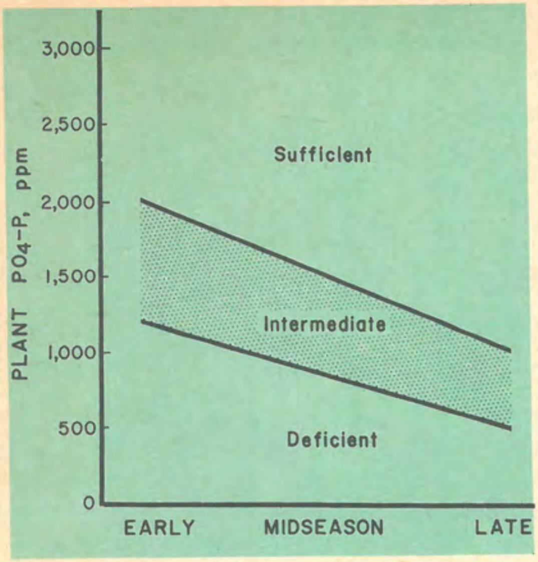
5 Lorenz and Tyler (Univ. of Calif.) used leaf analysis techniques on many vegetable crops to establish NO_3-N, PO_4-P and total K levels necessary for maximum production.

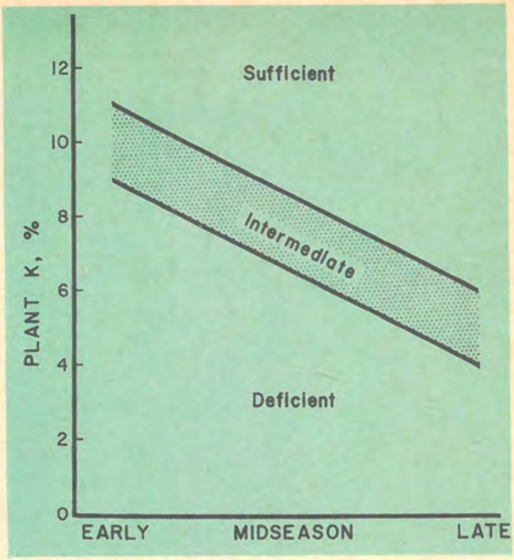
6 James A. Cook's (Univ. of Calif.) grape work confirmed former levels for the major nutrients and established levels in grape leaves for several micronutrients. Leaf analysis surveys and nutritional studies with grape varieties are bringing these subjects in the viticulture field to a more current status.

7 R. E. Blaser's extensive plant analysis research on alfalfa (VPI) indicates P content should be 0.26% or higher, K content 2.0 to 2.5% *for maximum yields.*

8 Much work has been done on corn. Hanway (Iowa State) found little or no yield increases when the content of the leaf opposite and below the ear at silking time is above 3.1% N, 0.33% P, and 2.0% K.

Agricultural scientists using leaf analysis have one big advantage over those in the medical field: plants can be subjected to any desired





mum production. Such data, developed by research workers, is provided to private laboratories for advising their grower clients.

This shows a typical procedure which is helping to advance the use and effectiveness of leaf analysis *not only for potato growers, but for growers of other crops.*

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condition without arousing the ire of the general public. In most cases, the medical research scientist must go through the "mouse to monkey" stage before approaching the human subject.

• ADVANCES IN STANDARDS: COLLECTING, ANALYZING, ETC.

A big advance in the use of leaf analysis—in the Far West at least—has been wide acceptance of standard methods of collecting and analyzing leaf samples of many crops, as well as the interpretation of levels. Standards for the plant part to sample, time to sample, deficiency symptom levels, and safe levels are shown on page 27.

For example, with pears the potassium deficiency level is 0.50% or lower and the safe level is 1.00% potassium. This is based on a sample of spur leaves taken between June 15th and July 15th. The University of California has published laboratory methods for analyzing leaf samples: widely accepted by both research workers and commercial agricultural laboratories.

• ADVANCES IN PRACTICAL USE—BY GROWERS

Crop logging (including analysis of leaves) has long been used in commercial operations by sugar planters and pineapple producers in Hawaii. Mainland United States growers have adopted leaf analysis slowly—until recently.

Today its practical use is increasing rapidly. State laboratory services, encouragement of commercial agricultural laboratories by re-

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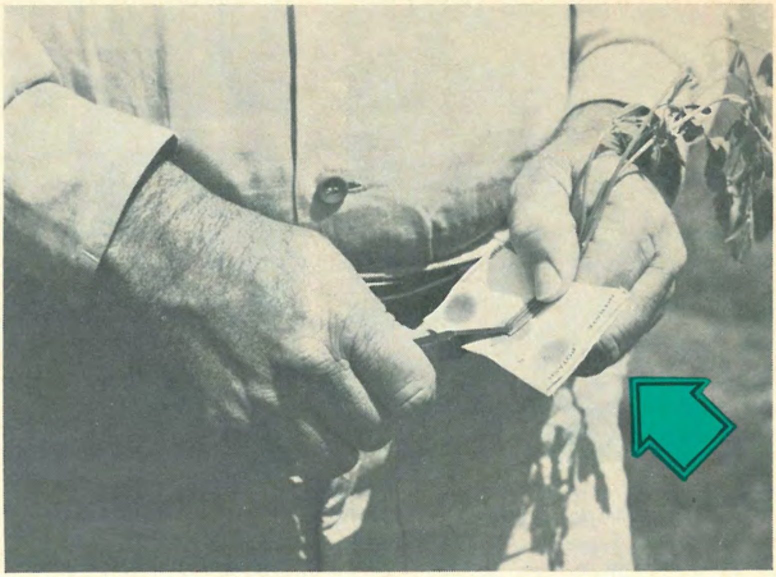


Ask The PLANT

G. A. WICKSTROM N. D. MORGAN A. N. PLANT

The nutritional problem of plants is being approached by two important types of tests—soil tests and plant tests.

Soil tests should be widely used to estimate the plant food available in the soil for plant use. But the final answer to plant nutrition and elimination of hidden hunger must come from the plant.

Recognizing a *deficiency symptom* has become routine to the trained field worker, though he will go to chemical methods of evaluation when any doubt enters his mind. In this process he has two choices: (1) to test plant tissue in the field, (2) to send samples of plant tissue into the laboratory for analyses.

• TISSUE TESTING HAS CERTAIN ADVANTAGES

On-the-spot tissue tests are easily, rapidly done. Without leaving the field, the tester can associate the results with the appearance of the crop. Test results that seem out of line can be re-checked immediately. If the main problem is *not* a shortage of N, P, or K as determined by the test, the crop can still be investigated.

Tissue testing provides an effective demonstration tool in explaining the problem to farmers. Tissue tests get us out in the field to take a close look—*firsthand!*

To the eye, without any comparison, a crop may look normal in all respects even though it may be suffering from HIDDEN HUNGER. Chemical tests on the plants are essential.

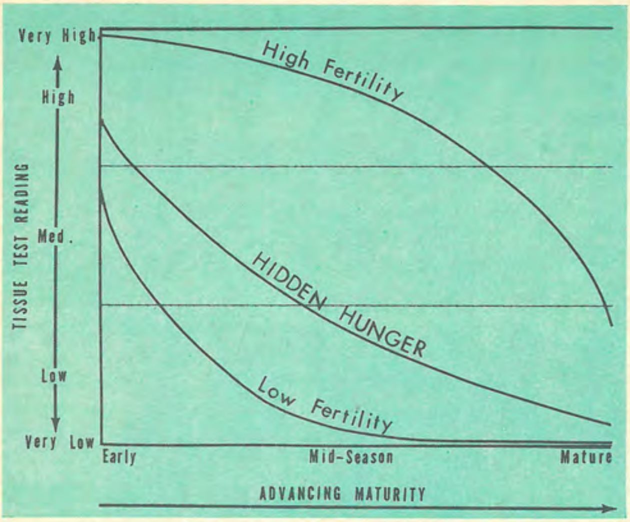
in the FIELD

● FIRST, YOU MUST TROUBLE-SHOOT CAREFULLY

In using tissue testing, one must investigate the crop thoroughly to be sure that something other than a shortage of N, P, or K is not limiting yields. *All production factors are interrelated.* Look for these "controllable" *limiting factors:*

1. Too low or too high pH levels.
2. Insect damage, roots or tops.
3. Disease symptoms.
4. Too high or too low plant populations.
5. Improper variety.
6. Improper placement of fertilizer.
7. Poor drainage.
8. Other management errors.

Should one be located, the plants in question may not or probably will not show true N, P, or K levels. Other factors—lack of moisture, hail, etc.—that we cannot control can do the same thing.



Very young plants will have high nutrient contents but will decrease with time. If fertility is low, plants will "run out of gas" by mid-season.

These plants ran out of K. Tissue tests supplied the answer before deficiency symptoms appeared.

TAKING THE PLANT SAMP

WHEN TO SAMPLE

Plants can be tested at any time sap is present since it is the succulen tion that must be used. Very young will have high nutrient contents. Pla proaching maturity are generally low trients in parts that can be tested. one test a season is to be made, the time for testing a plant is when it is greatest stress, usually at mid-season flowering and seed-setting begins. Th use of tissue testing is *repeated* sa and testing of the field throughout th son.

Caution: Know *What* fertilizer w plied and *How*. Starter fertilizers cc good levels early but plants can "run gas" if basic fertility is low. Also, plo fertilizers must be reached by roots tests may not give an accurate pic later nutrition.

Early-morning testing (before 9:0(or testing on very cloudy days may sh cumulations of nitrates that need s for conversion to other nitrogen fc there is any question, check again l the day or on another, better, day.

Nitrates may also accumulate in periods (when it's so dry that leaves v roll). Rain will wash nitrates that accu in the surface of the soil by evap down to the root zone, and plants w porarily show nitrates present even there is a deficiency. Don't test du drouth or immediately after a rain.

WHAT TO SAMPLE

Test enough plants to be repres of the field or area. Run tests imme

Vegetable crops have much differ quirements—higher K and sometimes so that special papers and chemica be needed. This can be done wit knowledge of what the levels of a pc crop should be.

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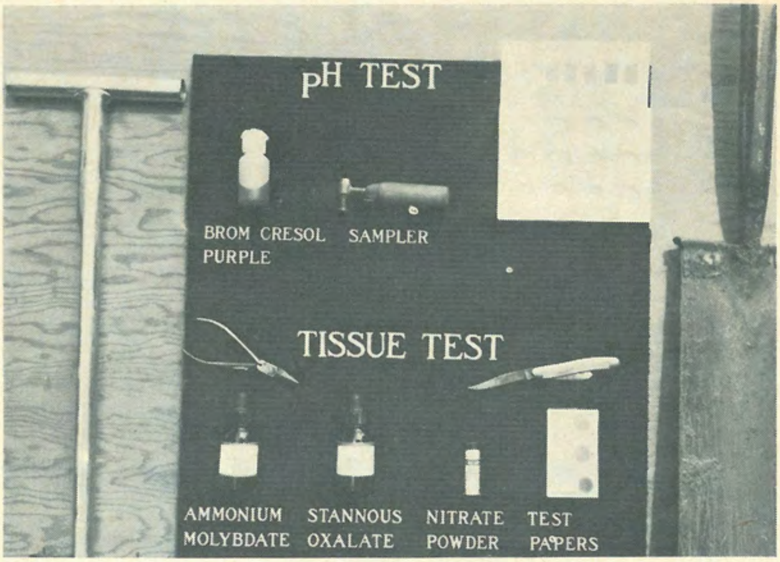
SAMPLING CHART

PLANT	TEST	PART TO SAMPLE	To avoid Hidden Hunger MINIMUM LEVEL
CORN			
Under 15″	NO_3	Midrib, basal leaf	High
	PO_4	“ “ “	Medium
	K	“ “ “	High
15″ to ear showing	NO_3	Base of stalk	High
	PO_4	Midrib, 1st mature leaf*	Medium
	K	“ “ “ “	High
Ear to very early Dent	NO_3	Base of stalk	High
	PO_4	Midrib, leaf below ear	Medium
	K	“ “ “ “	Medium
SOYBEANS			
Early growth to midseason	NO_3	Not tested	
	PO_4	Pulvinus (swollen base of petiole), 1st mature leaf*	High
	K		High
Midseason to good pod development	PO_4	Pulvinus, 1st mature leaf	Medium
	K	“ “ “ “	Medium
COTTON			
To early bloom	NO_3	Petiole, basal leaf*	High
	PO_4	“ “ “	High
	K	“ “ “	High
Boll setting to ⅔ maturity	NO_3	Petiole, 1st mature leaf*	High
	PO_4	“ “ “ “	High
	K	“ “ “ “	High
⅔ maturity to maturity	NO_3	Petiole, 1st mature leaf*	Medium
	PO_4	“ “ “ “	Medium
	K	“ “ “ “	Medium
ALFALFA			
Before 1st cutting	PO_4	Middle ⅓ of stem	High
	K	“ “ “ “	High
Before other cuttings	PO_4	Middle ⅓ of stem	Medium
	K	“ “ “ “	Medium
SMALL GRAINS			
Shoot stage to milk stage	NO_3	Lower stem	High
	PO_4	“ “	Medium
	K	“ “	Medium

* FIRST MATURE LEAF—Avoid the immature leaves at the top of the plant. Take the most recently fully matured leaf near the top of the plant.



THE TESTING KIT: various kits may differ, but most will contain the materials shown here: The pH kit is a simple one to add to the tissue testing kit and very important to the diagnostic process. For information on specific kits write to the following:

Denham Laboratory
Rt. 1, Wilmer, Ala.
(Vial and paper tests for NPK, soil P and pH.)

Urbana Laboratories
Urbana, Illinois
(Paper tests for NPK.)

Lee Lab
1412 Russell Blvd.
Columbia, Missouri
(Paper tissue test, paper and vial tissue test, and pH.)

• PILE UP EVIDENCE TO GET AT THE TROUBLE

Just as a bad case of indigestion requires research into recent intake of foods, so do we go to the soil test reports and fertilizer and cropping history to add to the tissue testing results. Compiling all the field information we can gather, *including tissue tests,* leads to conclusions about the crop. While we may suspect a shortage of N, P, or K, the tissue test can be the final evidence that cinches the case.

TESTING METHODS

• NITRATE NITROGEN

This is a test for the nitrogen form that has not yet been converted into other forms on their way to becoming part of the proteins in the plant. It is a reflection of the supply in the soil. Several methods are presented. Which you use is a matter of personal preference.

Glass Vial Method . . .

. . . can be used with red pigment containing plants such as cotton, where the paper test described next would be obscured. It is an excellent method to use for demonstration purposes. More accurate determinations are possible.

1 *Mash* well with pliers the ends of petioles (equivalent to ⅛ teaspoon) and place in a glass vial containing 5 cc. of distilled water.

2 *Stir* one minute with remaining unmashed petioles, washing out nitrate from mashed tissue.

3 *Discard* tissue, add nitrate powder in proportion to size of a small pea.

4 *Shake* and allow 5 minutes for pink or red color to develop.

Filter Paper Method . . .

1 *Place* cut end of tissue in a fold to the test paper.

2 *Apply* small amount of nitrate powder to cut end of tissue.

3 *Squeeze* fold with pliers through underside of paper, being certain sap comes into contact with powder.

4 *Allow* 5 minutes for color to develop.

Stalk Method . . .

1 *Split* stalk or tissue with clean, sharp knife.

2 *Apply* small amount of nitrate powder to cut tissue, gently mashing it into tissue.

3 *Allow* 5 minutes for color to develop.

READINGS (see cover): White—no nitrates. Pink—low. Light Red—medium. Cherry Red—high.

• PHOSPHATE PHOSPHORUS

Glass Vial Method . . .

1 Place 5 cc of dilute ammonium molybdate solution (phosphate reagent #1) in glass vial.

2 Mash and stir in tissue as described for nitrate test.

3 Stir 1 minute, discard tissue, then stir with tin strip or add small amount of stannous oxalate solution (phosphate reagent #2) to develop the blue color. (Tin strip preferred for cotton.)

Filter Paper Method . . .

1 Squeeze small amount of sap from cut end of tissue onto filter paper.

2 Add one small drop of ammonium molybdate (phosphate reagent #1) solution.

3 Add a bare drop of stannous oxalate solution (phosphate reagent #2) or rub lightly with the tin strip. (Avoid touching spot with fingers.)

4 Read color development.

Stalk Method . . .

. . . split the stalk and run test directly on plant tissue as described for filter paper method.

READINGS (see cover): No Blue color—very low. Light Blue—low. Medium Blue—medium. Intense Blue—high.

• POTASSIUM TEST

1 With pliers, squeeze small amount of sap from cut end of tissue onto each of dots on test paper. Allow 30 to 60 seconds for reaction.

2 Wash each dot with ammonium molybdate solution (phosphate reagent #1) to remove orange color that will wash out. Orange remaining where plant sap was squeezed on is the basis for the reading.

READINGS (see cover): No Orange left—very low. Orange, bottom dot—low. Orange, middle and bottom dots—medium. Orange, all 3 dots—high.

• WHAT THE TESTS MEAN—OR "ACCUMULATION EFFECT"

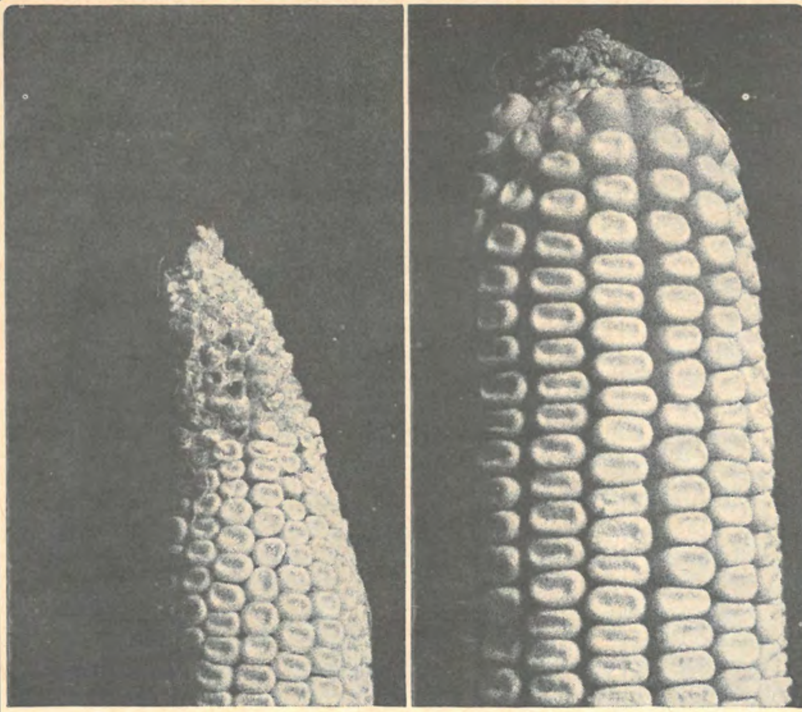
In using tissue testing we are looking for the one element, N, P, or K that *may* be limiting crop yields. One of them being very low may allow the others to "accumulate" because plant growth has been restricted. Therefore, we cannot assess any reading except for the limiting element.

For example, if NO_3 is very low, PO_4 and K may accumulate in the plant and the tissue test may show adequate amounts, even though the soil is low in P and K. This "accumulation effect" is more related to level of NO_3 and K than to PO_4, although low PO_4 can cause accumulation of NO_3 and K.

• TO AVOID HIDDEN HUNGER—HAVE SURE LEVELS

The application of plant food must be well above bare minimum if plants are to avoid "hidden hunger". Chemistry can help determine what these plant food requirements are by the use of tissue tests. The levels we find in plant tissue should be *SURE LEVELS*—high enough to guarantee no shortages of N, P, or K.

The End



From Page 17

search workers, and activities by the Agricultural Extension Service have stimulated more grower use of leaf analysis. Many large growers and farm organizations have set up laboratories where leaf analysis is an integral part of farm operations.

Leaf Sampling Explodes

Leaf analysis research on oranges has recently been carried into grove management practices on a large scale to determine nitrogen status of the trees. The Agricultural Extension Service has presented the advantages of a leaf analysis program and leaf sampling procedures to many grower meetings. The result: growth in leaf sampling programs from a few hundred acres five years ago to several thousand acres today! Leaf samples have been collected by individual growers and service personnel. In most cases, analytical work is performed by private agricultural laboratories in California.

The Ohio Agricultural Experiment Station, Department of Agronomy at Wooster, sponsors an analytical service on plant materials for Ohio farmers. Twelve elements are reported. Results and recommendations are returned through the county agent.

Profits Depend On Nutrient Levels

For many crops, critical nutrient levels in the leaves have been established from readily observed plant symptoms correlated with total yields. Interest is growing in the crop response zone *above the deficiency symptom level.*

Quality of the crop yield determines the returns to the grower. Such factors as *improved grade, shipping quality, processing quality* return greater profits. Leaf analysis techniques projected into this zone of higher yields and improved market quality have shown that *higher leaf nutrient levels* are necessary for insuring these greater profit factors.

Potash Paying Off

Use of leaf analysis to determine nutrient status and fertilizer need of orchards (deciduous fruits) and vineyards (grapes) has been growing steadily.

. . . On Deciduous Fruits & Grapes

To accomplish maximum benefits, leaf analysis has indicated that potassium deficiencies cannot be corrected by conventional amounts of potassium fertilizers in California. Sufficient nutrient absorption is attained only with initial heavy applications: 20 to 30 lbs. of sulphate of potash per tree or 4 to 6 lbs. per vine. Such massive amounts correct the deficiency and exert a residual effect for several years.

This type application is now in commercial practice and in many instances growers have found these heavy applications pay out the first year in *improved fruit size as well as yield.* Note what happened to fruit size of the pears and peaches in the graphs when potassium leaf content was 1.00% K or lower.

. . . On Cotton

Using leaf analysis to measure nutrient absorption, workers have found massive applications on cotton crops necessary to overcome potassium deficiencies. Even on sandy soil types, growers now use 600 to 800 lbs. muriate of potash to get the desired results.

THE END

A GUIDE: TO POTASH HUNGER SYMPTOMS AND LEAF SAMPLING SCHEDULE

Crop	Symptoms of K Hunger	Place to Take Sample	When to Sample	Hunger Evident
Apple	Leaf scorch first on basal shoot or spur leaves, progressing toward younger leaves as season advances. With continued deficiency, leaves become small, trees remain stunted, fruits fail in size.	Matured leaves on spurs, or leaves near base of current year's growth.	June 15 to July 15	When sample leaves analyze less than 1.0% K.
Apricot	Leaves tend to roll upward, lacking dark green color. Foliage tends to be sparse, shoot growth reduced. Marginal scorch frequently results. Die-back in severe cases. Yields and fruit size reduced. Threshold value higher since apricot leaf contains more K than other stone fruits.	Matured leaves on spurs, or leaves near base of current year's growth.	June 1 to July 15	When leaves, analyzed by standard procedure, show less than 2.0% K.
Almond	Tip burning of leaf early in season. Often marginal scorch near tip of leaf, causing boat shaped appearance, especially on leaves of vigorously growing shoots. Leaf color generally pale, resembling N shortage. Second growth cycle may occur from lateral buds of current growth. Continued K hunger causes small leaves, sparse foliage, poor growth, die-back of terminals, reduced bearing.	Matured leaves on spurs, or leaves near base of current year's growth.	June 1 to July 15	When sample leaves analyze less than 0.7% K. (Injury from sodium chloride also produces leaf scorch and low K content, but can be detected by high sodium or chloride analysis.)
Prune and Plum	Leaf scorch on both Japanese (P. Salicina) and European (P. Domestica) types. Excessive bearing (especially in prunes) intensifies severity of leaf scorch and resultant die-back. Fruits small and poor in color. For complete correction, control of cropping must sometimes be considered in addition to potassium applications.	Matured leaves on spurs, or leaves near base of current year's growth.	June 15 to July 15	When sample leaves analyze less than 1.0% K —realizing symptoms and leaf analysis can fluctuate markedly with alternate of light & heavy crops.
Peach	Generally not evident until late summer, intensified by heavy bearing. Longitudinal upward rolling of leaf most evident on terminal growth. First few basal leaves on a shoot frequently normal. Rolling more definite & distinct with proximity to terminals. Leaves pale green, showing some scorch along edges when rolling severe. Fruits small, poorly colored, ripen earlier than on normal trees.	Matured leaves near base of current year's growth.	June 15 to July 30	When sample leaves analyze less than 1.0% K.
Pear	Leaf rolling combined with silver brown discoloration of exposed underside of leaf. Leaves smaller, pale green. Tree sparse, shoot growth weak. Distinctly smaller fruits mature earlier. Leaf symptoms may not be distinct until harvest time.	Matured leaves on spurs, or leaves near base of current year's growth.	June 15 to July 15	When sample leaves analyze less than 0.7% K.

Meet Nutrient NEEDS

BY STANLEY A. BARBER PURDUE UNIVERSITY

Some farmers produce 150 bushels or more of corn per acre regularly. They also may produce 50 to 60 bushels per acre of soybeans and wheat, and 6 or more tons of hay per acre.

Only a few years ago, corn yields of 100 bushels per acre were considered high yields. Today yields over 100 bushels are the rule.

High yield production requires adequate plant nutrients and water for the growing crop plus good management practices for favorable crop environment.

Enough nutrients for a 100-bushel crop will not meet the demands of a 150-bushel crop.

• DETERMINE THE GROWING CROP'S NUTRIENT NEEDS

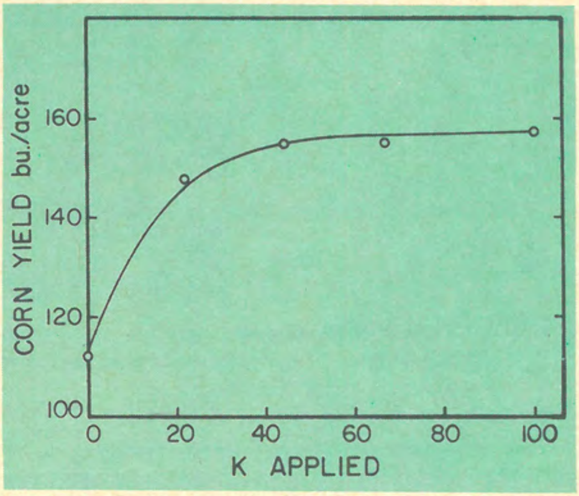
There are at least three ways:

1 Calculate the amount removed by the harvested portion of the crop.

We can make a chemical analysis of the grain (such as corn grain)

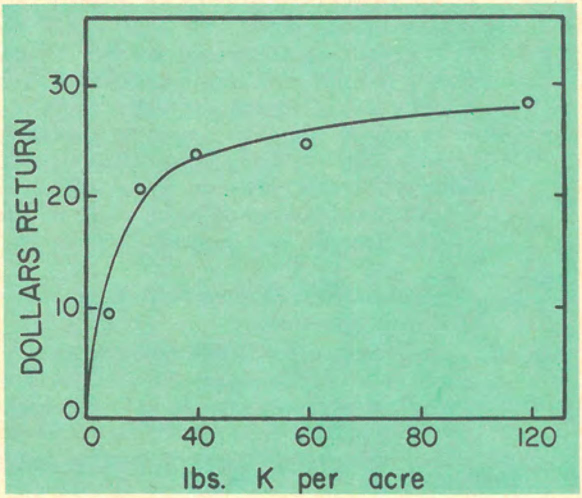
ARE YOU MINING AWAY YOUR SOIL NUTRIENTS? If so, you have plenty of company—in history. Historically crop production has been based on producing crops from the nutrients originally in the soil. Of course, soils vary greatly in the length of time they can be cropped before declining yields demand a specific nutrient. It pays to evaluate the fertility level periodically to estimate how much is in the "feeder" —to know for sure that you are not mining out more valuable nutrients than you are returning to the soil for future crops.

FOR HIGH YIELDS



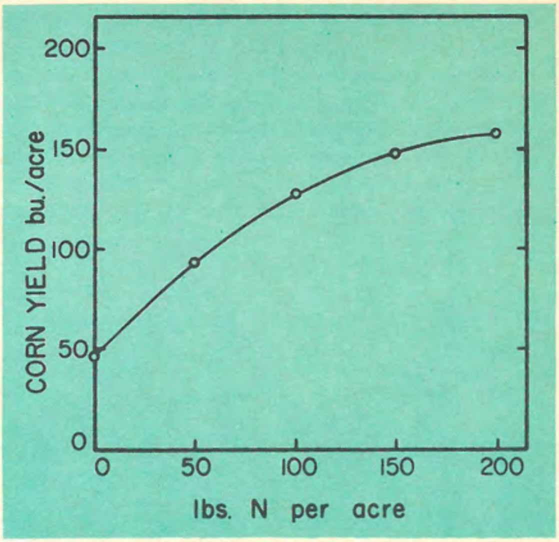
CROP YIELD usually climbs in this (curvilinear) fashion as we increase the amount of nutrients available. Here potassium application increased corn yield—a 4-year average for 1960-63. (K x $1.2 = K_2O$).

FOR DOLLARS RETURN



DOLLAR RETURNS climbed up to the highest (120 lbs.) K rate per acre. About 60 lbs. K (72 lbs. K_2O) per acre per year gave the most economical return in this corn, soybean, wheat, hay rotation.

WITH
NITROGEN



CROP YIELD climbed from annual applications of nitrogen on continuous corn. These results were averaged from 2nd, 3rd, and 4th year corn after legumes.

removed when we harvest a corn crop—or analyze a representative sample of the total plant removed when we harvest alfalfa for hay. Multiplying this crop's nutrient content by the total per acre weight of the portion of the crop removed will give the pounds of nutrients removed per acre.

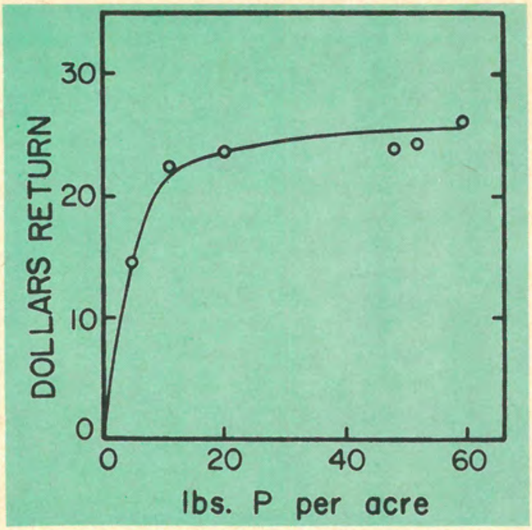
We must replace these nutrients removed or we will deplete the soil. In the past, we have frequently "mined" the soil of available nutrients because we did not return as much in fertilizer as we removed in cropping. Many soils were so depleted that crop yields declined greatly. Yet, replacing crop removals by fertilization will not supply enough for top yields on many soils. It will not even maintain the present fertility because some nutrients are lost by leaching and by soil erosion. So, this method may not be satisfactory.

2 Calculate the amount taken up by the plant during the growing season.

The supply of available nutrients in the soil *plus* that added in fertilizer must readily supply the *total need* of the growing crop or top yields will not be realized. Of the total absorbed by the crop, the portion discussed in step 1 will be removed and the remainder present in the crop residues is returned to the soil where it may be used by a later crop.

The soil will need to supply the total nutrient requirements readily. More than the minimum quantities must be present in the soil because plant roots can absorb only a part of that which is present in the soil.

WITH
PHOSPHORUS



DOLLAR RETURNS indicated a need for an average of 22 lbs. P (50 lbs. P_2O_5) per acre per year in this corn, soybean, wheat, hay rotation. ($P \times 2.29 = P_2O_5$).

3 Calculate the amount of each of the nutrients that is needed in the soil to give maximum production when all other nutrients are present in adequate amounts.

Basic information is available from laboratory, greenhouse, or field experiments.

The amount we need to add as fertilizer depends on the amount already present in the soil. The amounts needed to get top yields are usually more than that calculated in 1 or 2, especially where the soil tests low in the nutrient considered.

• HOW MUCH PLANT FOOD IS NEEDED FOR HIGH YIELDS?

Estimates of nitrogen, phosphorus, and potassium need shown here were calculated from a 12-year fertility experiment at the Purdue University Agronomy farm. Average yields from adequate fertilization showed this for the past 4 years:

CROP	1960-63 AVERAGE
Corn	156 bu/A
Soybeans	50 bu/A
Wheat	58 bu/A
Hay	4.8 tons/A

Both the total above-ground portion of the crop and the harvested

TABLE 1—NPK CONTENT OF TOTAL CROP AND OF HARVESTED PORTION IN A CORN-SOYBEAN-WHEAT-HAY ROTATION

Crop	Yield per acre	Total Crop			Harvested Portion		
		N	P	K	N	P	K
Corn	156 bu.	170	30	120	125	22	30
Soybeans	50 bu.	[185]*	22	100	[160]*	16	50
Wheat	58 bu.	125	22	90	75	15	13
Hay	4.8 ton	[240]*	30	180	[240]*	30	180
Total		295	104	490	200	83	273
Av./Yr.		74	26	123	50	21	68

* Most of Nitrogen supplied by legume bacteria.
P x 2.29 = P_2O_5; K x 1.2 = K_2O.

portion have been analyzed chemically—shown in Table 1. Since this was a corn, soybean, wheat, and hay rotation, we have also calculated the total need for the rotation. Since the legumes, soybeans and alfalfa in the hay, fix their own nitrogen, we have shown the calculations of this nitrogen in brackets. The totals indicate the need for this four-year rotation.

Modern farming practices frequently make it more economical to fertilize with phosphorus and potassium on the basis of the rotation rather than for each crop. These data indicate that we would need to apply at least an average of 21 lbs. P (48 lbs. P_2O_5) per acre per year and 68 lbs. K (82 lbs. K_2O) per acre per year to keep from depleting the soil of phosphorus and potassium.

● RESPONSE TO ADDED NUTRIENTS INDICATES NEED

There must also be enough nutrients in the soil to supply readily the quantities needed by each crop.

The response to added nutrients indicates the rate of fertilization needed on this Raub silt loam soil. The soil tested low in phosphorus (35 lbs. P by Purdue test) and low in potassium (100 lbs. K per acre) at the start of the experiment 12 years ago.

The need for nitrogen on corn is shown by results from a separate experiment on continuous corn. The same nitrogen rate was used on each plot year after year. Nitrogen has some residual effect so the yield increase from a particular nitrogen rate was due both to that added in the year the yield was obtained and to the residual nitrogen from the same rate applied in previous years.

Page 30 shows response of corn to nitrogen for the average yields of second, third, and fourth year corn. About 150 pounds of nitrogen was needed to produce continuous corn at the 150-bushel-yield level on this soil. If 150 pounds had not been used on the previous year's crop, more than this would be needed because less residual nitrogen would be available. Also less nitrogen is need where corn follows a legume crop.

HOW FERTILIZATION PAYS OFF IN DOLLARS

The dollar returns from phosphorus and potassium additions were calculated from the average response of the crops in the rotation of corn, soybeans, wheat and hay and represent the last 4 years in a Purdue experiment that has been going for 12 years. The values used were: corn, $1 per bushel; soybeans, $2.50 per bushel; wheat $2 per bushel; and hay, $20 per ton.

The relationships shown in the P and K dollar charts are the nutrient requirements when a 12-year fertilization period was considered. The most profitable rates are similar to the removals previously calculated. The amounts to get the top yield in a single year can be much greater than this, especially where the residual effect of fertilizer is not considered and the supply from the soil is low.

In this case, we have considered a long period of fertilization and the soils have been brought to a medium to high level of fertility. So, our nutrient requirements for phosphorus and potassium approximate removals.

IN SUMMARY

1 High crop yields require more fertilizer than lower yields.

2 Increased need for nitrogen is particularly noticeable.

3 Larger forage yields remove more potassium.

4 Fertilization applications need to be greater than removals to sustain high yield productions and provide a basis for higher yields in the future.

5 The farmer of the future will need a long-time fertility program.

The End

R. E. WAGNER W. K. GRIFFITH

MAXIMUM ECONOMIC YIELDS Are Cost-Cutters

We talk much about the great changes taking place in agriculture. But we seldom recognize that in one way farming is no different than it was 25 years ago. Today's farmer gets just about the same price for what he sells as he or his father did in the late 30's.

When it comes to what the farmer has to buy or use to keep his operation going, the story is different: feed costs doubled in 25 years; farm machinery costs more than doubled; farm labor costs more than tripled.

Fertilizer is the only major farm input that has held the line. On a plant nutrient basis, fertilizer cost increased only 10%. The average retail cost of a plant food unit was actually less in the early 60's than in the early 50's.

• COST-CUTTING A MUST—FOR THE FARMER

As we look to the future, it seems clearer all the time that the farmer's only hope for maintaining or improving his economic position —or even to survive in some cases—is to cut per unit production costs. The individual farmer can do little to get a better price for his product, except improve quality. But he can—and must—do more to cut costs.

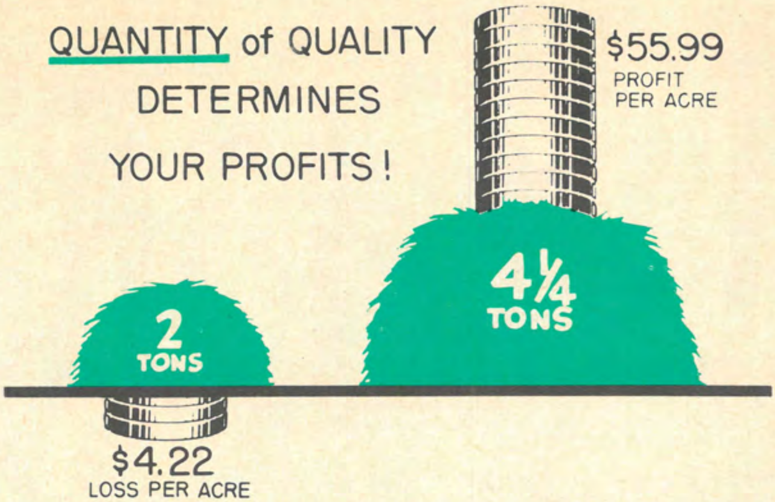
The future in farming does not look good for those who cling to yesterday's practices. But those quick to adopt today's and tomorrow's cost-cutting methods should stay in a competitive and comfortable position for many years to come.

• TOP YIELDS—TO REMAIN COMPETITIVE

For the farmer desiring to remain competitive and to earn a decent living, no substitute can replace high yields, whether they be of crops, of meat, or of milk. To discourage high yield farming—indeed, anything short of maximum economic yields—is to urge inefficiency. We all agree, I believe, that this should never become a part of any research, extension, or educational program.

With rising yields—usually up to high levels—production efficiency increases, unit costs drop, profits rise (Figure 4). Many examples illustrate the point. Take soybeans in Virginia: at a 20-bushel yield level,

Figure 1



It begins with efficiency.

Leading farmers now shoot for more than the average 2-ton hay yield reported by most states. They shoot for 5 to 6 tons for good economic reasons: to pull out of the red and well into the black.

production and harvesting costs would be $1.96 a bushel, shown in Table I. Doubling the yield to 40 bushels would drop costs to $1.27 a bushel—*and increase profits from 72¢ to $29.22 an acre!*

Nothing will do more for nearly all farmers than to shoot for top yields—for **maximum economic yields,** the level at which the last dollar spent to produce that yield returns a dollar. This means pushing all practices—fertilizer, lime, weed control, insect control, disease control, management, etc.—to the limit. If just one factor is neglected, maximum economic yields fall short of what could be attained, sacrificing profits (Figure 2).

• CORN YIELDS SKYROCKET IN JUST 10 YEARS

The extent to which maximum economic yield goals are now met

TABLE 1. COSTS AND RETURNS FROM SOYBEANS AT TWO YIELD LEVELS*

	20-bu. Yield	40-bu. Yield
Total cost/acre	$39.28	**$50.78**
Cost/bushel	1.96	**1.27**
Gross return/acre	40.00	**80.00**
Profit/acre	.72	**29.22**

* Based largely on figures from information prepared by the Virginia Polytechnic Institute, Agricultural Economics Department.

WHAT'S YOUR NEXT LIMITING FACTOR?

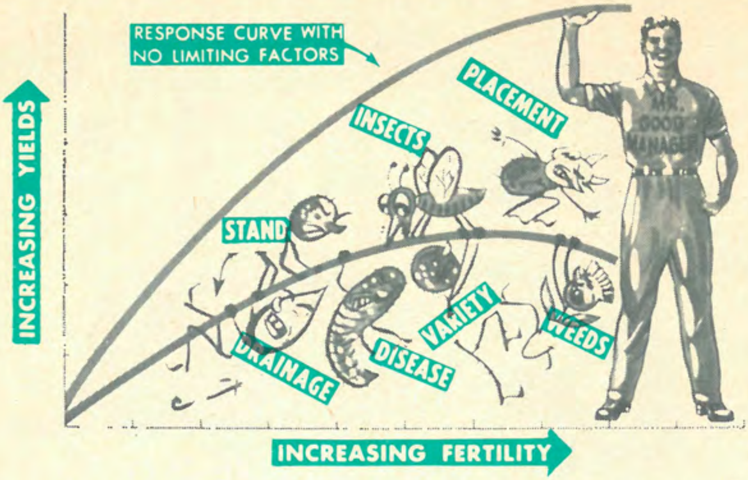


Figure 2

Many gremlins are at work.

Many factors can pull down your yields—and profits. Neglect to control just one of them and you fall short of maximum economic yields, the road to sure profits.

on the farm varies widely with the crop. Vegetable producers are probably coming close. Tobacco growers are not far off. Corn and cotton farmers are doing a better job than some.

Corn yields have skyrocketed in the past decade. For example, in 1954, the average Illinois corn yield was 50 bushels per acre—in 1959, 67 bushels; in 1962, 82 bushels. This past year in 1963, a new record of 85 bushels per acre was reached on more than 8 million acres of Illinois corn. This is a phenomenal record, especially on the total acreage involved.

Today, 100-bushel corn is old hat to many top farmers. They feel defeated if they don't top the century mark. Some are at the 150-bushel level. Others are pushing up to 200 bushels. If they don't make it, they want to know why!

A good example is Mr. J. H. Roadruck, a well-known Indiana farmer. He averaged 136-164 bushels of No. 2 corn per acre on his 320 acres of corn in recent years, but still wonders what's wrong with his corn (Figure 3). He is working to get a 200 bushel farm average. His average in the Five Acre Corn Contest the past 8 years is 217 bushels.

The winning yield in the 1963 Indiana Five Acre Corn Contest was 254 bushels per acre. The previous high was 243 bushels. Outside the Corn Belt this past year, some Delaware plots produced 225 bushels per acre.

Dr. E. H. Rinke of the University of Minnesota says, "In 15 to 20 years, 200 bushels per acre of corn will be as common as 100 bushels is today."

• BUT WITH FORAGES—A DIFFERENT STORY

The story is different with forage crops. The maximum economic yield kind of thinking is only beginning here. Farmers everywhere

Figure 3

. . . but top farmers outwork them.

Would you wonder what's wrong with your corn if you had averaged 136-164 bushels per acre on 320 acres of corn in recent years? Well-known Indiana farmer, J. H. Roadruck, typifies today's top farmer—working to get a 200-bushel farm average and wondering why not.

fall far short of full potential in both production and utilization of forage.

Average state yields of forages, reported in various surveys and the census, are at best little more than break-even yields as far as profits are concerned—and more often are well below the break-even point. The average yield of alfalfa and alfalfa-grass mixtures in most states is around the 2-ton level. Very few reach the 3-ton mark except where irrigation is a major factor.

• AND AVERAGE IS NOT ENOUGH

Why? Because today it takes most of 2 tons just to cover costs of producing and harvesting a hay crop. Yet, profits rise rapidly as yields increase above this level, *especially if quality is what it can be*. This is why leading farmers now shoot for 5 and 6 tons.

Look what it can mean. The Virginia Agricultural Experiment Station reported that a hay crop producing 2 tons per acre actually lost $4.22 on each of those acres (Figure 1). When fertilized and managed to produce 4¼ tons, a net profit of $56 per acre resulted. Cost of producing the low yield was $34.11 per ton, but only $18.76 per ton for the high-producing crop.

Many 2-ton forage producers are still in business. True. But other crops on the farm usually carry the load. Under these conditions, cotton or corn or some other crop is the profit-maker, while alfalfa just limps along—*but only because fertilizer and other production practices for top yields are not used.*

● FORAGE YIELDS CAN BE REVOLUTIONIZED

Through the new technology and information our researchers continue to grind out, plus experiences of top farmers, forage yields can be revolutionized much like the corn story. Top farmers recognize alfalfa and other high quality forages have maximum economic yield potentials sufficiently high to compete with even the latest corn production.

Last year a Kentucky farmer produced 8 tons per acre of alfalfa on a 14-acre field. He compares the 8 tons per acre of the kind of hay he produced to 200 bushels of corn in *feeding value*.

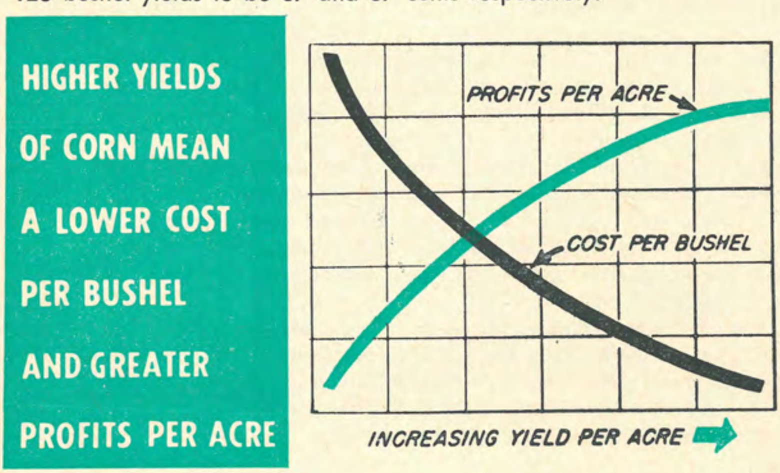
Better fertilization offers one of the best opportunities to realize full production potential from forages and many other crops. Why? Studies have found fertilizer responsible for 40 or 50% or even more of the fantastic corn yield increases. It is reasonable to expect sound fertilization can do as much for forage.

● AND FULL-FEEDING WILL HELP DO IT

Maximum economic yields of forage, or any other crop, are possible only if there is *adequate fertility available every growing day of the year*. To assure this, nutrients must be available in excess at certain times of the year. In his presidential address before the American Society of Agronomy, Dr. A. G. Norman said, "An ideal environment, indeed, may be one in which all nutrient elements are available to the point of slight luxury consumption at all times."

What we are saying in effect is that we need to put plants on a full-feed program, the same as we do livestock (Figure 5). Leaching losses would be of minor importance, except on sandy soils. Usually the added income from extra production would far exceed the cost of any fertilizer losses.

Getting as much as you can out of each acre is a major key to lower costs, rising profits. Ohio data show cost per bushel at 65 and 125 bushel yields to be 87 and 67 cents respectively.



Yields build profits . . .

Figure 4

CATALOG YOUR SOILS FOR THEIR POTENTIAL

Soils and climate largely set the limit on top yields if the farmer already uses and properly fits together the latest production practices. Many times soils can determine whether corn or alfalfa or some other crops should lead the acreage on your farm. Most soils will produce average yields of a wide variety of crops. But you narrow the combinations of soils and crops when shooting for top yields.

We need to catalog our soils more carefully. We need to know their production potential. What are maximum economic yields of different crops on various soils?

Virginia is pioneering a research program to get the answers to these questions. Other states—Maryland, Delaware, New Jersey, and Pennsylvania—are joining to make it a regional program.

Such information will show a farmer the capacity of his farm to produce various crops—and how far he is from his potential. It will pinpoint areas for maximum profits.

WILL WE BE READY WITH RESEARCH RESULTS?

This maximum economic yield approach can help raise our sights in research and extension. We must learn how to meet the needs of tomorrow's farmers. Is it too much to expect research agencies to produce crop yields *well beyond those produced by top farmers?*

If Dr. Rinke and others are right—or even close to it—better yields represent a real challenge for our researchers. Research now on the drawing boards will be ready for use by farmers 5 or 10 years hence. Will its results be of value to and challenge top farmers of *that day?*

The End

Planning a full-feed program for your crops is as basic as full-feeding your livestock. That means adequate fertility available every growing day of the year.

. . . and full feed builds yields.

Figure 5