BETTER CROPS

with plant food

Spring 1987

Take a closer look at crop fields in 1987

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ALFALFA in low fertility conditions suffered from the dry weather in 1986.

Fertility Can Help Stretch Available Soil Moisture

By A. Morris Decker and Lester R. Vough

High soil fertility levels are important for maximum economic forage yields. Maryland research also shows the advantage of fertility as a hedge against extended drought.

TOP FORAGE yields can be obtained when soil fertility matches crop needs, providing that adequate soil moisture is available. An added benefit in periods of moisture stress is that a good fertilization program can help make the most of available moisture. This was dramatically brought into focus during the 1986 summer drought in Maryland with precipitation from March 20 through October 31 being 12.73 inches below normal; more than half of that deficit occurred during May, June and July.

A legume-grass-soil fertility experiment was seeded in the fall of 1984 to look at yield responses and fertilizer requirements of legume and legume-grass mixtures. Alfalfa and red clover were seeded alone and in selected combinations with eight different grasses into three soil fertility regimes that had been established in previous research.

Table 1 gives the soil test levels for the three fertility treatments prior to seeding the test. Since establishment, fertilization has been aimed at maintaining these potash differences. The total amounts of K_2O applied since establishment through the 4th harvest of 1986 have been 773, 386, and 193 lb/A for the high, medium, and low fertility treatments, respectively.

Table 1. Soil test values obtained prior to seeding the experiment.

Fertility level	pH	P_2O_5	K_2O
Low	6.99	130 H	131 M
Medium	7.14	213 VH	236 H
High	7.18	426 VH	433 VH

Data presented are only for alfalfa and red clover grown alone and in combination with orchardgrass, since general trends were similar among the other legume-grass mixtures. Total forage yields for these four treatments for the

Dr. Decker and Dr. Vough are forage researchers, University of Maryland.

first two harvest years are given in **Table 2.** In the first full harvest year, red clover and red clover-orchardgrass showed significant responses to fertility level and were more productive than the alfalfa combinations at all fertility levels. However, in 1986 alfalfa treatments were more productive.

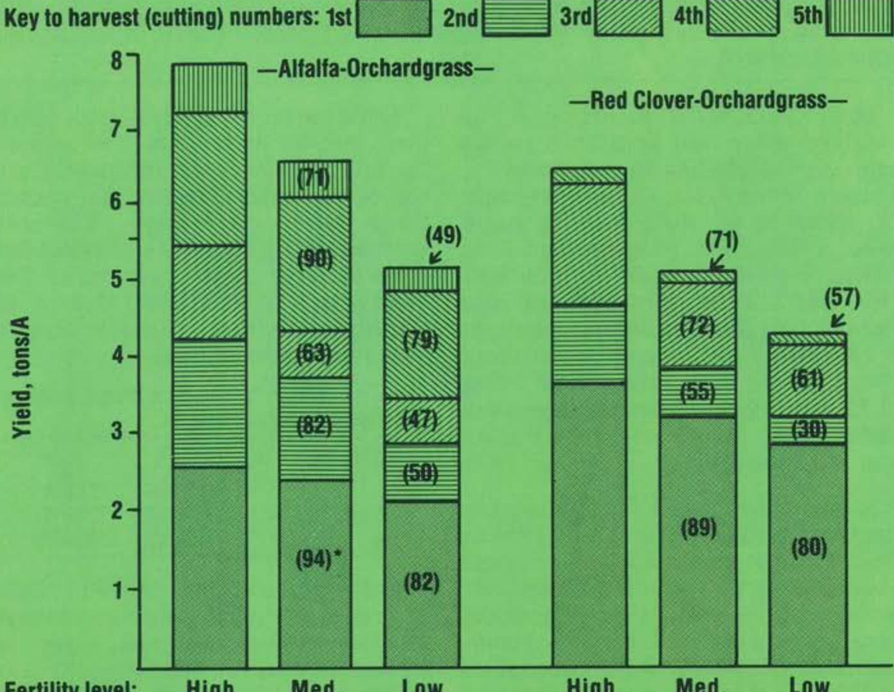
Table 2. Total dry matter production from alfalfa and red clover grown alone and with orchardgrass at three soil fertility levels.

Fertility Level	Alfalfa		Alfalfa-orchardgrass	
	1985	1986	1985	1986
	——tons/A——		——tons/A——	
High	7.23	7.06	8.00	7.86
Medium	6.79	6.59	6.96	6.60
Low	5.12	5.65	5.96	5.23
	Red clover		Red clover-orchardgrass	
High	9.31	5.57	9.78	6.57
Medium	8.62	4.08	8.77	5.19
Low	7.83	3.11	7.87	4.38

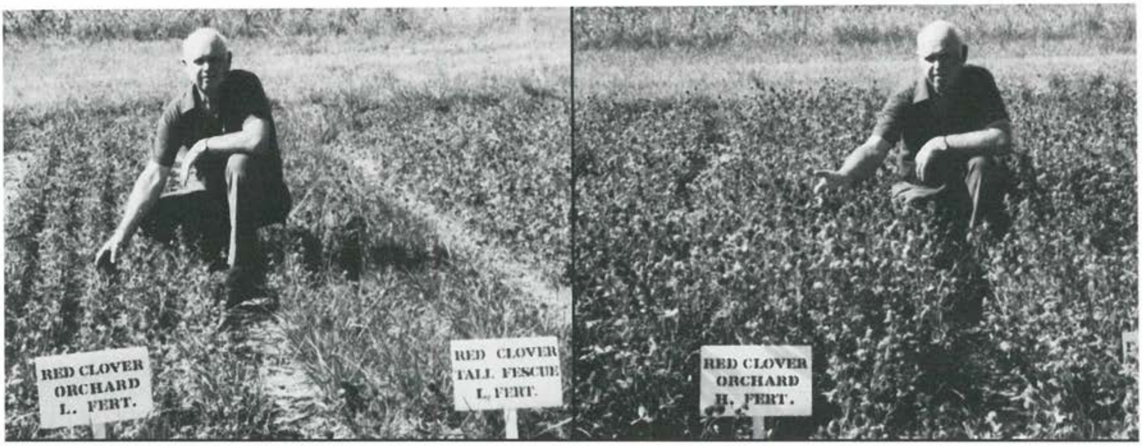
Kenstar, one of the more persistent red clover varieties under our conditions, was used in this study but stand thinning was still rapid after the first full harvest season. At the end of the 1986 season the best red clover stands were at the highest fertility level and the poorest stands were on the lowest fertility plots. Red clover stand loss was most severe with the most aggressive grass species, tall fescue. Alfalfa also showed a yield response to fertility level in both years, but very little yield reduction occurred from 1985 to 1986 in spite of the severe drought.

Available soil moisture plays an important role in dry matter production. **Figure 1** shows individual harvest yields for the two legume-grass mixtures for 1986. In the first harvest, when

Figure 1. Yields by harvest for alfalfa-orchardgrass and red clover-orchardgrass at three fertility levels (1986).



*Numbers in parentheses are percentage of forage produced of that grown at high fertility for that particular harvest.



DRAMATIC DIFFERENCES in the moisture-starved forage plots shown above are due to fertilizer. Dr. A. Morris Decker, University of Maryland forage researcher, compares low fertility plots on the left with high fertility plots shown at right.

adequate soil moisture was available, yields were excellent in both mixtures.

First harvest yields for the medium and low fertility treatments ranged from 80 to 94% of the high fertility level (percentages are in parentheses). Red clover stands had not yet started to thin significantly and yields were still higher than alfalfa treatments. It should be pointed out, however, that red clover mixtures had 11 more days to grow than alfalfa treatments before the first harvest.

The most severe drought conditions occurred during the third harvest growth for alfalfa and during the second harvest growth for red clover. The effects of drought and the importance of a good fertility program were most striking during these stress periods. **Figure 1** shows the low and medium fertility levels produced just 47 and 63% of the high fertility treatment for the alfalfa mixture and 30 and 55% for the red clover mix during these periods.

Soil moisture data would have allowed us to look at forage yields per inch of available water, but these data were not available. However, production per inch of precipitation was calculated. Alfalfa grown alone at low fertility produced 81% as much forage per inch of rainfall as alfalfa at high fertility. For the alfalfa-orchardgrass mixture, where the grass competed for both water and nutrients, the low fertility treatment produced only 47% as much forage per inch of water as the high fertility treatment. **It appears that as moisture stress increases, fertility management plays a greater role.**

It should be pointed out that soil fertility markedly affected botanical composition of the legume and legume-grass swards. Weeds were essentially nonexistent in 1985 but were much more of a factor in 1986 at the low fertility levels, especially when a legume was seeded without a grass. At the low and medium fertility levels some grasses are beginning to dominate the swards while at high fertility the legume, especially alfalfa, has all but eliminated most grasses. Tall fescue, at this time, appears to be the most persistent grass at all fertility levels. Note the photos above where both mixture and fertility effects can be observed. Red clover stands are already declining rapidly in the lower fertility treatments, and by the end of 1987 growing season the same may be true for the low fertility alfalfa-grass combinations.

It appears obvious from these preliminary results, along with other research at Maryland, that maximum economic forage yields require high fertility levels. These high fertility levels can also serve as a hedge against extended drought, provided a satisfactory forage stand is maintained.

While forage yields can be significantly increased by seeding a grass with either alfalfa or red clover, extra potash fertilizer may be needed to maintain the desired legume-grass mixture. Red clover does respond to high fertility management but it appears not to be able to compete with alfalfa beyond the first full harvest season. ■

Skills for Diagnosing Crop Problems Can Increase Yields and Profits

By Larry Sanders

Opportunities for higher crop yields and greater profits are missed if deficiencies or other problems in crop fields aren't properly diagnosed. In agriculture, as in most ventures, planning is essential for success. This article discusses factors which must be recognized and managed for maximum economic yields (MEY).

THOSE FARMERS who produce highest yields and profits have a plan to match their management systems with the right crops and soils under favorable climatic conditions. While there is not much a farmer can do to change climate, some management decisions can help modify its extremes.

Some diagnostic techniques can help identify field problems quickly, and then indicate changes needed in the system to increase yields and profits while minimizing risk.

Look For and Diagnose Yield-Limiting Factors All Season Long

Regular diagnostic field visits should be conducted throughout the growing season. Fields must be monitored closely to identify threshold levels of some pests and determine if treatment is needed. This results in maximum benefits and reduced risk.

It is important not to spend too much time on fields where problems are not present. However, spending additional time in problem fields can sometimes make the difference in yields and profits.

Develop a pattern. Use a diagnostic approach that develops a pattern in identifying the factors which limit crop yield. For example, consider the following procedure.

First, observe the **crop** aboveground and record any unusual visual symptoms.

Second, look at and record any apparent limiting factors in the **soil** and below-ground plant parts.

Third, keep a record of the **climatic conditions** affecting growth.

Fourth, evaluate **production practices** related to observed problems. Note the impact of timeliness and cultural practices on crop growth.

A permanent record of these observations for your file is important. As you plan for the next crop, a review of the information will definitely help make management plans.

Record keeping can take various forms. An example of a "checklist" appears on pages 10-11 following this article.

Early season. Look for yield-limiting factors early in the growing season to help resolve problems in the current crop and modify practices for next year.

Compaction and erosion are two continuing production problems with serious implications for long-term productivity in some fields. Early planting is popular in many areas and may con-

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tribute to higher yields for most crops. However, there is a fine line between planting too early and planting early enough to take advantage of high yield opportunities.

Early season can be a good time to scout for visual nutrient deficiencies. Phosphorus (P) and zinc (Zn) deficiency in corn are two characteristic symptoms which show up early, especially when poor growing conditions cause stress on young plants. Seedling growth and color can be a good indicator of crop vigor.

In many instances, nutrient deficiencies may not be visible when in fact plants are suffering from "hidden hunger". Crops with this condition may produce lower than normal yields although deficiencies are not obvious.

Of course, weeds, insects and diseases are always concerns in crop production. However, proper identification and control of early season pests can give a large response in crop yields and profits.

Mid-season. Grain formation is a critical time in crop production, when many factors can directly influence crop yields. Remember, nutrient supply and balance are critical for high yields.

Mid-season is a good time to take plant tissue samples for laboratory analysis. Don't forget to include a soil sample for improved interpretation of tissue samples. Also, be sure to note the climate and soil conditions prior to and at the time of sampling.

Various types of photography can be used to detect stress due to nutrient deficiencies or other factors. For example, aerial, color, and/or infrared techniques can sometimes help spot conditions which aren't apparent otherwise. However, careful observation in the field and other analysis will be needed to

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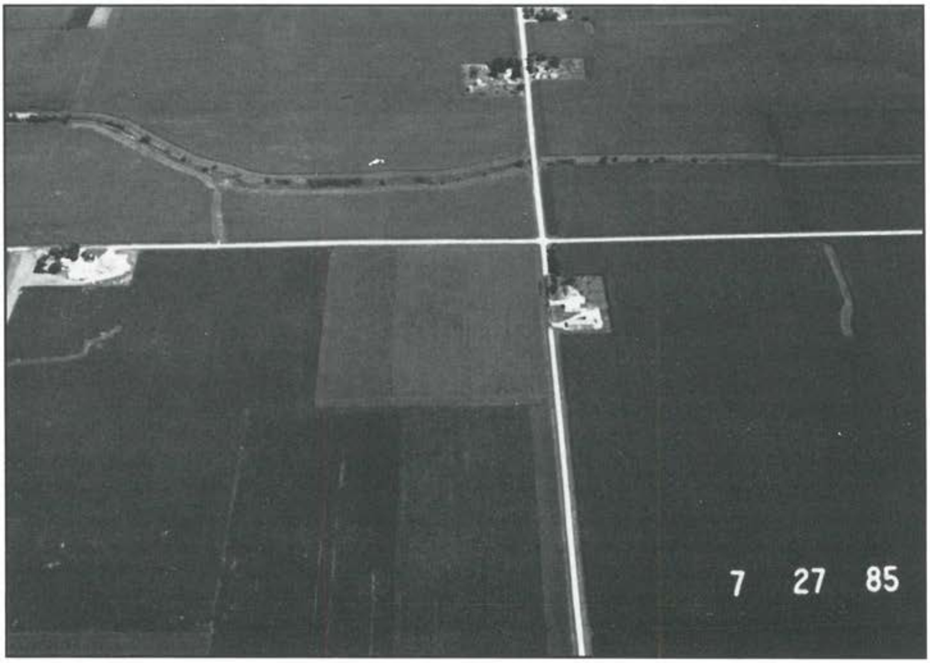


PHOTOGRAPHIC methods sometimes add another dimension to crop problem diagnosis. This scene is from an aerial color infrared photo taken in Illinois.
(Photo courtesy Top-Soil Testing Service Co.)

interpret the information. Nutrient problems, moisture stress, insect damage, crop disease, and many other factors may be confused or may interact to show some symptoms.

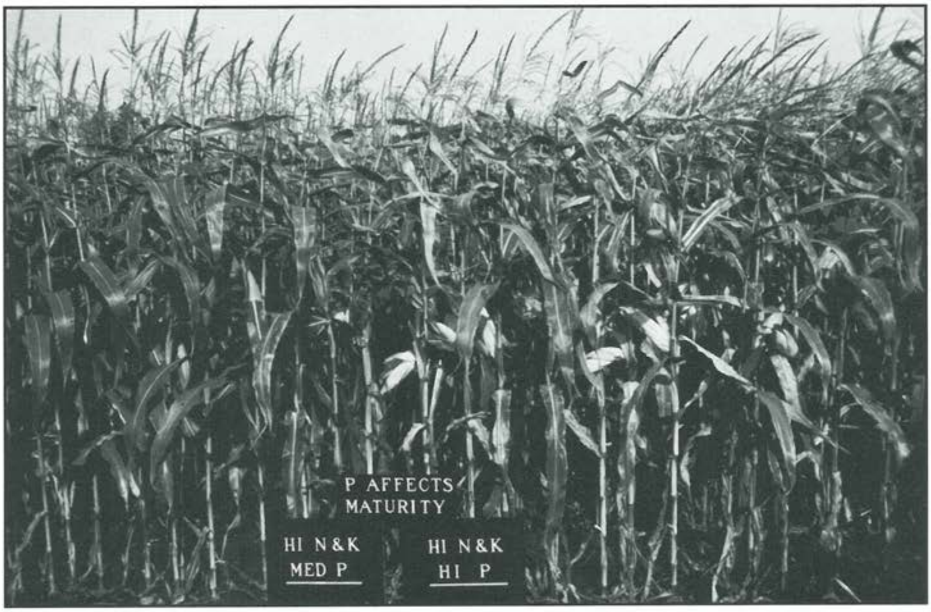
Look for plant discoloration. For example, yellowing of leaf margins of older corn leaves beginning at the leaf tips usually indicates potassium (K) deficiency. Tan leaf lesions with brown borders of older leaves may indicate southern corn leaf blight.

It takes time and study to differentiate many of the nutrient deficiencies from insect and disease infestations, but close observation is the key. Most universities and extension offices provide pamphlets with photographs of locally important insects, diseases, and nutrient deficiency symptoms.

Monitor the developing crop for insect and disease infestations. Also, mid-season is a good time to check the plant root system. Problems can now be identified which might arise from lack of root development related to hardpans or plowpans, root damage from nematodes or root profile modification due to early season flooding or compaction. Unlike weather conditions, soil fertility is a controllable factor which also has a large effect on crop yields. The crop diagnostician's job is to monitor these controllable factors and determine if they are limiting.

Late season. Late season crop inspections are also useful. Look for lodging, stalk diseases, late or early crop maturity, and grain quality problems. The photo below shows the effect of P soil test on crop maturity. Corn grown with high N and K with high P soil test had earlier maturity and higher yields than corn grown under the same conditions with a medium P soil test. Earlier crop maturity is a bonus that is often overlooked.

Farmers today more than ever need to obtain maximum economic yields (MEY). A good crop diagnostician can help farmers move toward MEY by



THERE WAS a marked effect of phosphorus (P) on maturity in these plots. The high P fertility resulted in corn silking five days earlier in 1985 and two days earlier in 1986. This could mean a bonus in higher yields and earlier harvest.

identifying key inputs and management techniques that are critical for improving yields and increasing profits.

Summing Up – Use All the Tools Available

The key to successful crop diagnosis is to look for those factors that limit crop production. It takes time and requires a dedication to close observation of the crop. Further, it means learning how to identify and separate problems caused by diseases, drought stress, low fertility, insects, weeds and other yield-limiting factors. Finally, it means a commitment to correcting those problems.

Many tools are available to assist in diagnostic work, ranging from a simple soil test probe or spade to aerial photography with color-coded readouts that characterize soil and moisture conditions, disease infestations and other yield-influencing factors. There are experts available from the universities, industry and local extension service. Soil tests and plant analyses give answers on nutrient deficiencies and imbalances.

None of the tools will be of value unless they are used. However, developing the art of crop diagnosis . . . using the tools . . . then following up to correct problems . . . can make the difference between profitable crop production and disappointment. ■

Diagnostic Tools

THERE ARE MANY TOOLS available to the crop diagnostician – all the way from the basic spade for digging up plant roots to aerial photography with color coded computer enhanced readouts which provide farmer information on soils, crops, and irrigation practices. Some of the important diagnostic tools that are useful are listed below:

- Magnifying glass or hand lens – to help identify and examine disease symptoms and small insects
- Knife – to examine plant tissue
- Soil probe – to examine soil profiles and take soil samples
- Tile probe or clothes hanger – to look for subsurface compaction
- Spade – to examine roots for soil penetration, insect damage or unusual growth characteristics
- Bags – plastic and paper containers for collecting insect, weed, disease, soil, and tissue samples
- Plant analysis – to help identify limiting nutrients and diagnose visual deficiencies either through critical level or DRIS (Diagnostic Recommendation Integrated System) analysis
- Soil test – to help identify limiting nutrients and plant fertilization progress
- Tissue testing kit – for quick test of plant tissue and soil pH
- Camera – with color and/or infrared film to document problem areas
- Field map – to take notes and mark locations of problems, etc.
- Tensiometers – to monitor soil moisture conditions. ■

A CHECKLIST such as this can serve as a useful record for future crop management decisions or for diagnosing field problems.

Crop Production Checklist for Maximum Economic Yields (MEY)

Grower ______________________

Address ______________________

____

Telephone ______________________

Date __________ **Field Number/Name** __________

Crop ______________________

Location ______________________

Consultant ______________________

Soil and Tillage Information

Soil type ______________________

Tillage method: Moldboard Plow __________ Chisel __________ No-till __________ Other __________

Describe primary tillage method ______________________ Date __________

Describe secondary tillage methods ______________________ Dates __________

______________________ __________

Other comments on soil and tillage:

Cropping Information

Acres __________ Yield Goal __________ Top Yield to Date __________ Crop Last Year __________ Yield __________

Variety or hybrid ______________________ Seed dealer ______________________

Seed: Germination % __________ Vigor test __________ Other details ______________________

Row spacing (in.) __________ Seeding rate __________ Depth __________ Planting date ______________________

Final population (plants/acre) ______________________ Harvest date ______________________

Field appearance: Poor ______ Fair ______ Good ______ Excellent ______ Other ______________________

Obvious deficiency (D) or toxicity (T) symptoms:

N _____ P _____ K _____ Ca _____ Mg _____ S _____ B _____ Zn _____ Cu _____ Mn _____ Fe _____ Other __________

Field Tissue Tests: (VL, L, M, H, VH) Plant part __________ Method __________ Date ______________________

Best area: N ______ P ______ K ______ Other ______________________

Poor area: N ______ P ______ K ______ Other ______________________

If additional tests are done, note here and attach a record of results.

Have plant analyses been taken from problem areas? __________ When? ______________________

When were soil samples last taken? ______________________ Results available? __________

Fertilization Practices

Method		N	P_2O_5	K_2O	Secondary Nutrients	Micronutrients
		pounds applied per acre				
Broadcast	Before Plowing					
	After Plowing					
	Topdress					
Row	Starter					
	Beside/below seed					
	With seed					
	Sidedress					
Foliar						

Other (manure, rate) ______________________

Type of Lime ______________________ Year applied ______________________ Rate __________ CCE, % __________

General Observations of Field Conditions

This checklist is available as a single sheet, 8½ x 11 inches, printed front and back. See page 23 for details.

Crop Protection Chemicals

List:	Formulation	Rate	Method of application/incorporation	Date/Time/Conditions
Herbicides				
Insecticides				
Fungicides				
Other Products				

Herbicide history	**Last year**	**Two years ago**
Chemicals & formulations:	____	____
Rate per acre:	____	____
Method of application:	____	____
Crop injury (description):	____	____

Crop Survey Records

Crop Description:

Growth stage (avg. 10 plants) ____ Plant height (avg. 10 plants) ____
Stand count (per 10 ft. of row) ____ Is rooting restricted? ____ Describe ____
Other notes ____

Weeds Present:

Kind (number per 10 ft. of row) ____

Insects Present:

Kind (threshold level) ____

Diseases Noted:

Kind (severity) ____

Other problems noted:
Temperatures, etc. ____

Moisture Conditions:

Seasonal observations for this crop ____

Rainfall (total/year) ____ **Rainfall (3 months-growing season)** ____
Does soil have "field capacity" to supply moisture for top yields? ____
Any crusting to reduce water intake? ____
Did crop have times of "wet feet"? ____ When? ____
Any wilting periods during growing season? ____ When? ____
Did hot winds occur during pollination? ____ Temperature (°F) ____

Irrigation used:

Type of system: Sprinkler ____ Gravity ____ Other ____

Record of irrigation:	Date	Rate (inches/acre)	Growth stage	Nutrients added (rate)
	____	____	____	____
	____	____	____	____
	____	____	____	____
	____	____	____	____
	____	____	____	____

Other comments:

Crop Production Checklist forms available from Potash & Phosphate Institute (PPI), 2801 Buford Hwy., NE, Suite 401, Atlanta, GA 30329

Fertilizer Recommendations from Soil Tests: Expectations and Limitations

By David W. Dibb

Making fertilizer recommendations for top profit returns is always a challenge, but probably even more critical in today's agricultural climate. An understanding of some of the resources available in making a sound recommendation will help us recognize some of the limitations, therefore allowing more realistic expectations.

SOIL TESTING provides some of the most basic information necessary in making a good recommendation. Note that it is not the only information necessary, but it *is* indispensable in most situations. It is well to remember that soil testing is not an end in itself but it is simply a means to an end . . . attaining a higher profit per acre.

Limitations

Although many limitations are inherent within the soil testing process, an understanding of these can make the total process even more helpful in making recommendations.

1) Taking the sample. The soil test is only as good as the sample that is taken. If a sample is taken from the corner of the field closest to your house and a recommendation requested for a field you own across town, you will likely receive an erroneous recommendation. The lab will assume that you have done your part . . . taking a sample that appropriately represents the field for which the recommendation is requested . . . correctly. This is an extreme example, but illustrates how vital it is to learn to sample in a manner that correctly represents the field.

2) Number of samples (intensity of sampling). If a soil sample is taken properly, the soil test results can accurately represent a relatively large area. But a composite sample taken over too large an area or an area with too much variability can hide differences which, if known, are useful for making more economically accurate recommendations. Research results from a soil test study show the potential advantages of an intensive sampling program. **Figure 1** shows a diagram of a field, indicating where the samples were taken, and the corresponding soil test results.

Table 1 includes a listing of the sample results.

Figure 1. Field map of sample sites and soil test results for pH, phosphorus and potassium.

1 pH 5.8 P_1 86 K 248	2 5.6 46 280	3 5.5 42 268	4 6.0 28 300
8 6.8 20 216	7 5.6 34 280	6 5.1 115 270	5 5.7 35 310
9 6.4 26 560	10 6.2 30 340	11 6.8 28 212	12 5.7 92 840

(Source: Dr. T.R. Peck, University of Illinois)

Dr. Dibb is Vice President of the Potash & Phosphate Institute (PPI).

Table 1. Soil analyses data from field #1.

Sample #	pH	P_1	K
		— — lb/A — —	
1	5.8	86	248
2	5.6	46	280
3	5.5	42	268
4	6.0	28	300
5	5.7	35	310
6	5.1	115	270
7	5.6	34	280
8	6.8	20	216
9	6.4	26	560
10	6.2	30	340
11	6.8	28	212
12	5.7	92	840
Avg.	5.7*	49	344

*Since pH is a logarithmic scale, to get the arithmetic average, it is necessary to convert to concentration, take the average and then convert back to the logarithmic scale.

While a quick review of the data does not show consistent differences in this case from top to bottom or side to side, this information provides the potential for spot treatment with prescription fertilization and may be one of the greatest values of a more intensive soil sampling program.

The arithmetic average of these 12 soil samples, which would essentially represent a single composite sample from these same locations across the field, is pH, 5.7; P_1, 49; and K, 344.

An ordering of the data from low to high gives another interesting perspective of the soil fertility condition in the field. **Table 2** includes both the arithmetic average, which would be analogous to a composite sample, and the median or mid-point of the range of values.

The arithmetic average pH (5.7) is quite close to the median of the soil tests in the more intensive sampling, while the "average" P and K tests are much higher than the median.

The P and K test distribution in the more intensive sampling of the field is not well represented by the arithmetic average test (composite). At least 75% of the samples fall below the average in each case. Therefore, 50% or so of the field might be underfertilized in a field such as this where considerable variation exists.

Table 2. Distribution of soil test values.

pH	P_1	K
5.1	20	212
5.5	26	216
5.6	28	248
5.6	28	268
5.7	30	270
— avg 5.7		
5.7	34	280
— — — —	median	— — — —
5.8	35	280
6.0	42	300
6.2	46	310
	— avg. 49	
6.4	86	340
		— avg. 344
6.8	92	560
6.8	115	840

This shift upward of P and K average values can easily happen because there is theoretically no upper limit to a test value, but a lower limit of zero precludes any undue downward effect on the "average" test.

For example, the extremely high K test in sample #12 (840) distorts the average K value upward by about 45 lb/A. Sample #6 for P (115) similarly shifts the average upwards by about 6 lb/A. In contrast, the lowest values in the range only influence the K and P "averages" downward by 12 and 2.5 lb, respectively.

With the information from the more intensive sample, these "very high" areas might be easily explained. Sample #12, because it is *very* high in both P and K might be the location of a former feedlot or farmstead. The high P test on #6 could be the result of hitting a location where there was spillage of a high-P starter fertilizer when loading a planter.

A farmer or advisor might want to go back and re-sample these areas to see how representative these samples really were. If real, resources can be shifted from these to other areas in the field where good economic returns could result from a higher application.

Once an intensive sample has been taken, a less intensive sampling procedure in subsequent years would be adequate for sound recommendations.

(continued on next page)

This could be based on many factors: soil types, drainage areas, past cropping history, etc; but this would be very difficult to do appropriately without the initial intensive sampling effort.

The most recent data summary available from the USDA Extension Service indicates that in the North Central Region, one soil sample was taken for each 191 acres of harvested crops. Even if a three-year sampling schedule is assumed, 64 acres is a large field to be represented by one soil sample . . . on the average.

3) Laboratory Analysis. This is generally the most sophisticated and accurate part of the soil testing process. With modern instrumentation, elements can be detected down to parts per billion. Most labs have up-to-date equipment, trained personnel, use standard accepted procedures and routinely run standardized check samples in every batch of samples to insure that quality control is maintained. These criteria should be reviewed along with price and service (turnaround time and follow-up on samples with unusual results) when a soil testing lab is being selected.

4) Correlation Information. After the soil test results are obtained, the recommendation is made by reviewing results from research performed to measure the response to applied nutrients on crops grown under varying management and climatic regimes. This is called soil test correlation. Because it is financially and logistically impossible to cover all combinations of crops, soils, management levels and weather variability, recommendations are derived from averaging the response from various locations over several years.

This means that a crop grown with a unique management system on a specific soil may show a greater or lesser response to an added nutrient than the correlation averages might predict. This is one of the reasons that it is so important that correlation research be continued at high yield levels and incorporate all new production innovations as they are developed.

Table 3. Scale of reliability, usefulness and cost effectiveness of soil tests.
(100 = very high 0 = of little value)

Soil Test	Rating
pH	100
Phosphorus	85
Potassium	80
Boron (alfalfa)	60
Boron (corn & soybeans)	10
Iron (pH > 7.5)	30
Iron (pH < 7.5)	10
Calcium	40
C.E.C.	60
Sulfur	40
Zinc	45
Available nitrate N	50

(Source: Dr. T.R. Peck, University of Illinois)

The strength of correlation information might be described very subjectively by a scale from 0 to 100 estimating the reliability and usefulness of information on various nutrients or soil test parameters. Dr. Ted Peck of the University of Illinois has made his own rating on this basis (**Table 3**).

Others would undoubtedly rate these somewhat differently. A low rating does not mean that this test may not be valuable under certain circumstances—for instance, with plant analysis in hand, many of the secondary and micronutrient tests become much more valuable.

The point is that even P and K tests, which are excellent, are not totally infallible or exact with regard to specific recommendations.

This degree of uncertainty is also reflected in a table which summarizes Purdue University soil test correlation information on P and K with regard to probability of a profitable response at various soil test levels.

It's interesting to note that at a high soil test level there is still a modest

Soil test P and K	Probability of profitable P or K response
very low	96 - 100%
low	70 - 95%
medium	40 - 70%
high	10 - 40%
very high	0 - 10%

opportunity for a profitable response. At very high levels the probability is very slim. This probability might also be described in another way: The percentages represent the probability of **lost profits** if P and K are not applied. With this perspective, it's easier to see why an important objective is to build soils to "high" levels and keep them there through adequate P and K applications. A farmer today cannot afford to gamble on losing profit opportunities.

The value of good and up-to-date correlation information at high yield levels cannot be overstated when considering the limitations and expectations of fertilizer recommendations.

5) Other Supporting Information. As noted in the discussion of correlation information, the soil test in and of itself is of little value unless further information is available. Even with a good soil test correlation base, further information can help make the recommendation more accurate.

The following analogy might be considered:

You are feeling pretty good but would like to feel better. You mail in to the lab a sample of blood and urine for analysis. Yet, no respectable physician would dare make a recommendation on the basis of that analysis without seeing you and acquainting himself with your medical history. You would not expect him to do so. Does this mean blood tests and urinalyses are worthless? Certainly not, but it does suggest limitations.

As in this medical case, with soil testing, the more complete the supporting information, the better the recommendation. Yet, many send in soil samples with no further information and expect very specific information in return. Following are a few items of supporting information that are helpful in making more specific recommendations.

- Crop to be grown
- Yield goal
- Previous cropping history
- Previous fertilization history
- Previous soil test records
- Tillage program
- Buildup or maintenance program
- Previous yield history
- Observed problems
- Plant analysis
- Moisture limitations
- Variety or hybrid to be grown—responsiveness?
- Plant population
- Soil classification information—productivity index
- cation exchange capacity (C.E.C.)

The importance of this and other supporting information on making recommendations is reflected in a comment from Dr. Bill Segars, State Soil Fertility Extension specialist in Georgia:

> "Even with the same soil tests, Georgia recommendations for fertilizing corn can vary as much as 50%, depending on the farmer's yield goal, level of management, and cropping systems."

6) Nitrogen. As part of the fertilizer recommendations, nitrogen rate is one of the components of considerable importance . . . both in terms of total nutrient costs and returns. It is important to point out that in states with fairly high rainfall such as Indiana, that soil test has no direct effect on the N recommendation. These recommendations are made strictly based on the "supporting information" that is made available and other observations, along with yield response . . . not soil test . . . correlation information. This re-emphasizes the need for good "supporting information" when a fertilizer recommendation is requested.

Soil Testing—Its Greatest Value

With all of the emphasis on recommendations, the greatest value of a continuous soil testing program may be missed. That is the soil test value itself. It is a measure of the soil fertility level of the soil. With long-term soil test information, soil fertility trends can be monitored. Are levels dropping or building? Is this year's test out of line with the long-term trend? If so, why? If

(continued on page 17)

Interactions of Corn Hybrids and Plant Population in Maximum Yield Research

By C.K. (Ken) Stevenson

Maximum yield research has put a spotlight on positive interactions which can greatly enhance yields and profits. In this multi-year study in Ontario, it's clear that some, but not all, corn hybrids respond to higher plant populations by producing higher yields.

MAXIMUM yield corn research at Ridgetown College of Agricultural Technology has been an ongoing project from 1982 to 1986 at Chatham, Ontario. The soils at this site are a Clyde silt loam with a pH of approximately 7.2 and a soil test rating for phosphorus (P) and potassium (K) of very high.

The highest yielding treatments have varied over the 5-year period from a low of 249 bu/A to a high of 293 bu/A **(Table 1).** It is interesting to note that not only are these yields high for this region, but they are also exceptionally consistent.

Increasing the rate of plant nutrients from high (300 lb N, 83 lb P_2O_5 and 200 lb K_2O/A), to very high (600 lb N, 183 lb P_2O_5 and 350 lb K_2O/A plus secondary and micronutrients) resulted in a significant yield increase in only 2 out of the 5 years. The lack of response to plant nutrients in this experiment is attributed to the fact that the P and K soil tests are both very high at the Maximum Yield Project site.

The interaction of hybrids and plant population per acre (ppa) had the greatest effect on increasing corn yields especially in the first three years (1982-1984). The grain yield with Pioneer 3707 was increased by 35, 28 and 39 bu/A in 1982, '83 and '84, respectively, when the plant population was increased from the recommended (25,500-26,100 ppa) to very high levels (36,400-39,400 ppa).

In 1984, yields of Pioneer 3707 were increased by 39 bu/A by increasing plant populations up to 39,400 ppa. The hybrid PAG 2890 had higher yields at recommended populations, but showed only a 7 bu/A response to increasing plant population.

Some hybrids may show a negative response to increased plant population.

Table 1. Maximum yield corn research results at Chatham, Ontario from 1982-86.

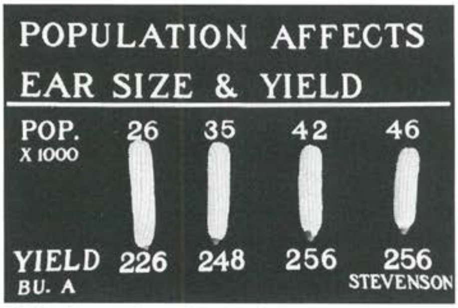
Year	Yield (bu/A)	Hybrid	Plants per acre	Fertility Rate	Irrigated
1982	251	Pioneer 3707	36,600	Very High	Yes
1983	249	Pioneer 3707	37,600	High	Yes
1984	257	Pioneer 3707	39,500	High	Yes
1985	293	Pioneer 3540	41,800	Very High	Yes
1986	263	Pioneer 3540	41,100	Very High	Yes

Mean (5-year) = 262 bu/A

Mr. Stevenson is Soils Specialist with Ridgetown College of Agricultural Technology in Ontario, Canada.

Although Asgrow Rx622 hybrid recorded good yields at recommended populations, increasing to 37,000 ppa in 1983 reduced yields of this hybrid.

Both hybrids tested in 1985 (Pioneer 3707 and Pioneer 3540) responded similarly to increased plant population. On the average, increasing the plant population from recommended (about 25,500 ppa) to very high levels (about 41,700 ppa) resulted in a yield increase of 39 bu/A (2.5 mt/ha). Pioneer 3540 outyielded Pioneer 3707 by 20 bu/A (1.3 mt/ha).



THIS illustration shows that a population of 42,000 plants per acre maximized corn yields for Pioneer 3540 hybrid in 1986 tests at Chatham, Ontario.

The photo shows the effects of plant population on ear size and yield of Pioneer 3540 during 1986. Results were similar for hybrid XC 456. As plant population increased from 26,000 to 42,000 ppa, both hybrids increased their yields. In this experiment it appears that a plant population of approximately 42,000 maximized corn yields.

Table 2 shows the effects of plant population on ear weight of two Pioneer hybrids in 1986 plots. As plant population increased, ear weight decreased. However, under our experimental conditions, an ear weight of about 0.4 lb gave the highest yields at the indicated plant populations.

Maximum yield research has uncovered several yield enhancing and possibly profitable interactions which deserve further study under our conditions. Maximum yield research in the future will concentrate in the areas of nitrogen × hybrid interactions, hybrid × plant population interactions, and P and K rate studies for maximum economic yields (MEY). ■

Table 2. Effects of plant population on corn ear weight (1986).

Population per acre	26,000	35,000	42,000	46,000
	— — — — — Ear weight (pounds) — — — — —			
Hybrid A (XC 456)	.50	.45	.42	.38
Hybrid B (Pioneer 3540)	.57	.49	.44	.39

**(Soil tests...
continued from page 15)**

so, the recommendation is probably incorrect. What is your long-term soil fertility goal? Are you achieving it?

None of these things can be evaluated by looking only at the recommendation. Get full value from the soil test by recording and monitoring the soil test level over a period of years. Then by adding other pertinent information, an excellent and profitable fertilizer recommendation can be made that fits the individual field and individual farmer's management.

Walter Schirra, former U.S. astronaut on Apollo 7, has stated regarding information:

> "Extraordinary achievement begins with information. Make that information easily and instantly accessible and you set your energies free to explore the upper limits of the impossible."

In making fertilizer recommendations, nothing is more true. ■

Note: A revised folder titled "Soil Testing in High-Yield Agriculture" is available from PPI. See page 23 for details.

Here's How to Estimate Yields for Corn and Soybeans Before Harvest

By Harold Reetz

Check these useful suggestions on methods of estimating corn and soybean yields in the field before harvest. Accuracy of estimates can be improved by sampling more areas of the field and careful attention to measurements required.

MANY GROWERS like to have an estimate of crop yields in the field prior to harvest. Such estimates can be helpful in making rough comparisons in hybrid/variety trials, checking yield variability over a field or among fields, or comparing different management treatments.

Various procedures have been proposed for such estimates. Some are more accurate than others. None will be as accurate as harvesting the entire area and weighing the harvested grain.

Given the limitations of estimates, they can still be valuable, if not for accurate yield determination, at least for making relative comparisons. The following are examples of procedures for estimating corn and soybean yields.

The estimates are based on collecting representative samples and projecting the yield from the harvested samples. Selecting representative sampling sites is very critical. Individual characteristics of the particular corn hybrid or soybean variety, or any unusual environmental conditions or management factors may affect the accuracy of the estimates. But they can be useful in making rough, relative comparisons.

Estimating Corn Yields

This procedure is based on information used in developing the "Corn Yield Calculator" slide rule published by the University of Illinois:

1. Count number of ears in 1/1,000 acre:

Row Width (inches)	Length Equal to 1/1,000 acre
20 in.	26 ft., 1 in.
28 in.	18 ft., 8 in.
30 in.	17 ft., 5 in.
36 in.	14 ft., 6 in.
40 in.	13 ft., 1 in.

2. At the same site, select three representative ears and count the number of rows of kernels and the number of kernels per row for each ear. Do not count tip kernels that are less than half-size.

3. Estimate the yield for EACH of the three ears as follows: (Number of ears in 1/1,000 acre) × (number of kernel rows) × (number of kernels per row) × 0.01116 = bushels per acre at 15.5% moisture.

4. Average the yield estimates from the three ears.

5. Repeat steps 1 to 4 at several sites and average the results to estimate grain yield for the entire field.

Variations in test weight and kernel size can affect comparisons. It would be most likely to provide accurate relative comparisons in yield for different fields or treatments using the same hybrid.

Accuracy can be improved by making the estimates for several areas within a field and averaging the estimates.

Dr. Reetz is Westcentral Director of the Potash & Phosphate Institute (PPI).

Estimating Soybean Yields

It is more difficult to make a reliable estimate of soybean yields. The following procedure is offered as a general suggestion, but not a precise method.

1. Count the number of plants in 1/1,000 acre in 10 different randomly selected areas of the field:

Row Width (inches)	Length Equal to 1/1,000 acre
7 in.	75 ft., 1 in.
10 in.	52 ft., 2 in.
20 in.	26 ft., 1 in.
30 in.	17 ft., 5 in.
36 in.	14 ft., 6 in.

For narrow rows, it may be easier to count plants in a rectangular area. For example, for 7 in. rows, count the plants in five rows, each 15 ft. long, or 10 rows, each 7 ft. 6 in. long.

2. To select a random sample, choose a point in the row, then count down the row ten plants; pull up this plant and count the pods on it. *This selection procedure is important to avoid any bias in selecting plants for the pod count.* Repeat for at least 20 plants. (The more plants on which pod counts are taken, the more accurate the estimate.)

3. Calculate the average pods per plant:

Total pods/number of plants on which pods were counted = pods per plant

4. Number of plants in 1/1,000 acre × average number of pods per plant = total pods

5. Calculate grain weight:

Total pods × 0.4024 grams per pod = total grams

Total grams/453.6 = total pounds

6. Calculate yield equivalent:

[(Total pounds in sample) × 1,000]/60 lb/bu = bu/acre

As with the corn yield estimate procedure, accuracy can be improved by sampling more areas of the field.

An alternative calculation procedure for steps 5-6 is based upon the assumption that there are 2.5 seeds per pod and 2,500 seeds per pound.

5. Calculate seeds per acre:

Pods per acre × 2.5 seeds per pod = seeds per acre

6. Calculate pounds per acre:

Seeds per acre/2,500 seeds per pound = pounds per acre

7. Calculate yield:

Pounds per acre/60 = bu/A

If a more accurate measurement of seeds per pound or pounds per bushel is available, substitute the appropriate numbers in the calculations.

The accuracy of these procedures depends very much on the accuracy of the plant counts and pod counts. ■

Corn Hybrids Respond Differently to Fertilizers and Population

By M.H. Miller and W.A. Mitchell

Researchers continue to increase understanding of differences in corn hybrid response to fertilization, population and other management factors. This article features results from 1985 and 1986 studies at the University of Guelph, Ontario.

TWO CORN HYBRIDS (Pioneer 3949 and Asgrow Rx308) have shown marked differences in response to nitrogen (N), phosphorus (P), potassium (K), and population in a two-year experiment at Guelph, Ontario, Canada.

The experiment was conducted in 1985 and 1986 on a silt loam at the Elora Research Station. Treatments included (in addition to the two hybrids) two populations: 26,300 and 36,400 plants per acre (ppa); and irrigation (trickle) versus no irrigation. The study included six combinations of the following nutrient applications:

- N_1 - 134 lb N/A (as NH_4NO_3) preplant incorporated
- N_2 - 134 lb N/A preplant incorporated + 178 lb pre-emergence
- N_3 - 134 lb N/A preplant + 45 lb N/A at 2-week intervals beginning mid-June to provide total of 312 lb/A
- P_1 - Recommended 20 lb P/A as 13-52-0 with planter
- P_2 - Fall 1984 - 312 lb P/A incorporated
  Spring 1985 - 20 lb P/A as in P_1
  Spring 1986 - 67 lb P/A incorporated
  - 20 lb P/A as in P_1
- K_1 - Recommended K - spring 1985 - 89 lb K/A preplant incorporated
  Spring 1986 - 53 lb K/A preplant incorporated
- K_2 - Fall 1984 - 592 lb K/A incorporated
  Spring 1985 - 89 lb K/A preplant incorporated
  Spring 1986 - 127 lb K/A preplant incorporated

Magnesium (Mg) and zinc (Zn) - all plots received 89 lb Mg/A and 18 lb Zn/A in the spring of 1985 and 23 lb Mg/A in the spring of 1986 as preplant incorporated application.

Soil tests taken in the fall of 1985 are shown in **Table 1.** The soil pH on the plots ranged from 7.5 to 7.8.

Table 1. Available P and K in soils, fall 1985.

$NaHCO_3$-Ext P	Exchangeable K
ppm	ppm
15	101 (Recommended P & K)
53	143 (Very High P & K)

The highest yield was obtained in both years with Pioneer 3949 at high population and the highest fertility input. This yield was 152 bu/A in 1985 and 148 bu/A in 1986. These yields are well above average for the region.

There was a small (6.5 bu/A) but significant response to irrigation in 1985 but no response in 1986, a year with above average rainfall. There were no significant interactions between irrigation and the treatment variables in 1985. Hence the irrigation and no irrigation

Dr. Miller is a Professor and W.A. Mitchell is a senior technician in the Department of Land Resource Science, University of Guelph. This project was supported by PPI and Ontario Ministry of Agriculture and Food.

Table 2. Differential response of two corn hybrids to N rates and population in 1986.

population ppa	Pioneer 3949 N_1	N_3	Response to N	Asgrow Rx308 N_1	N_3	Response to N
	bu/A at 15.5% moisture					
26,300	133	134	1	125	135	10
36,400	139	147	8	126	136	10
Response to population	6	13		1	1	

data have been combined in all further discussions. There was no response to time of N application (N_2 vs N_3) in either year.

Population × N × Hybrid

There was no response to N application above the recommended rate (134 lb N/A) in 1985. There was a significant response to N in 1986 due probably to the high rainfall resulting in either leaching or denitrification.

In 1986, the population × N × hybrid interaction was significant. Pioneer 3949 responded to additional N only at the high population **(Table 2).** The response of Asgrow Rx308 to N was greater than that of Pioneer 3949 and was the same at both populations.

Also apparent from **Table 2** is the fact that Pioneer 3949 responded much more to the increased population than did Asgrow Rx308.

P × K × Hybrid

Both hybrids responded to applications of P and K in excess of the recommended rate in both years. However, there was a P × K × hybrid interaction in both years **(Table 3).** The response of Asgrow Rx308 to both P and K was independent of the level of the other nutrient. However, the response of Pioneer 3949 to P or K was greatest when the other nutrient was also at the higher level. Asgrow Rx308 gave a response to P and K as great or greater than Pioneer 3949 at the recommended rate of the other nutrient. However, the response of Pioneer 3949 to either P or K was about double that of Asgrow Rx308 when the other nutrient was at the higher level. Although the response of Pioneer 3949 was not sufficient to pay for the large amount of additional fertilizer applied, the results indicate that this hybrid would respond profitably to higher rates of fertilizer than Asgrow Rx308.

These results suggest the need to assess more thoroughly the responsiveness of corn hybrids to management inputs such as fertilizer and population. It is not feasible to test all hybrids to determine their responsiveness. Soil fertility specialists must work more closely with crop breeders in an attempt to determine the genetic components that are involved in these responses. Only then will we be able to fully capitalize on this genetic variability. ■

Table 3. Differential responses of two corn hybrids to P and K averaged over two years.

	Pioneer 3949 P_1	P_2	Response to P	Asgrow Rx308 P_1	P_2	Response to P
	bu/A at 15.5% moisture					
K_1	129	136	7	120	128	8
K_2	131	147	16	125	133	8
Response to K	2	11		5	5	

THE PROBLEM: Stunted vine growth and poor fruit set of grapes.

Plant Problem Insights

for Maximum Economic Yields (MEY)

PHOSPHORUS (P) deficiency can reduce vineyard profits in many ways:

- **Lost yield**
- **Premature maturity or senescence**
- **Uneven maturity**
- **Reduced vine vigor**

Grapes must have an adequate supply of all the essential elements to produce a uniform, high quality crop of maximum profit potential.

Phosphorus (P) is essential for both plant growth and reproduction. When phosphorus is deficient, overall plant growth slows. Trunks will be spindly, canes short and leaves will turn different hues of yellow through red depending on the variety.

Deficient (symptomatic) leaves are found intermingled with healthy green leaves throughout the plant. However, a relatively greater proportion of immature terminal leaves will exhibit deficiency symptoms. In white wine varieties, such as Chenin Blanc, the primary and secondary veins remain green while the tissue between the veins becomes lemon-yellow. Symptoms first appear on the leaf margin, at least for mature leaves, and eventually cover the entire leaf surface. See field photo at left. Also, symptoms are shown at left in the top close-up photo.

In red wine grapes, such as Cabernet Sauvignon, the coloration of deficient leaves is distinctly different. Interveinal tissue yellows and turns red producing islands of red tissue surrounded by yellow-green veins. Again, symptoms are the strongest and initial necrosis occurs near the leaf margin. The lower close-up photo shows healthy leaf at right, deficient symptoms at left.

Phosphorus deficiency can severely affect grape cluster formation. Fewer clusters form per vine. Those clusters that do form are smaller, many without wings, and have poor set and shot berries.

Both soil and tissue testing will give useful information in establishing a balanced fertilizer program that includes phosphorus. It may take several years before the vines are fully recovered. Also, the best response to phosphorus may not come until the second year after application. Annually monitoring phosphorus levels in the tissue will indicate if the fertilizer program is on target.

NOTE: Phosphorus deficiency can lead to low levels of magnesium in the leaves. Therefore, symptoms may vary somewhat depending on the influence of magnesium. ■

This message is available on a 3½ × 7½-inch information card. See page 23.

Information Materials from PPI

Quantity **Cost**

Fertilize Corn for Maximum Economic Yields

This completely revised and updated slide set covers fertilization and other key management practices to consider in a modern corn production system. The set contains 61 slides: **$15 per set ($10 MC*), with printed script.** ________ $ ________

Crop Production Checklist for Maximum Economic Yields

As a record, reference, or diagnostic tool, this checklist form can be useful for increasing crop yields and profits. A single sheet, front and back, 8½ x 11 inches. See pages 10-11.
Cost: 10¢ each (5¢ MC*) ________ $ ________

Plant Food Uptake (PFU), for crops by region

Handy wallet-size cards list nutrient needs of crops at various yield levels, and the amounts removed in crop harvest. (Specify region: Midwest __ South __ Great Plains __ West __) **Cost: 15¢ each (10¢ MC*)** ________ $ ________

Plant Problem Insights for Maximum Economic Yields

See page 22. This is a colorful series of photo-cards, each with a concise discussion of a specific field problem, along with positive tips for increasing yields and profits. Specify choices: **Mid-season Potassium Deficiency of Cotton __ ; Stunted Vine Growth and Poor Fruit Set of Grapes __ ; Poor Early Corn Growth __ ; Weak and Thinning Alfalfa Stands __ ; Lodged Corn __ ; Poor Early Wheat Growth __ ; Soybean Cyst Nematode __ .**
Cost per card: 10¢ each (5¢ MC*) ________ $ ________

Soil Testing in High-Yield Agriculture

This updated and revised folder answers a series of questions and points out the benefits of soil testing. **Cost: 25¢ each (15¢ MC*)** ________ $ ________

***The MC symbol indicates Member Cost: For members of PPI, contributors to FAR, to university and government agencies.**

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Most Efficient Yield

CALL IT what you will—"MEY"—"Most Efficient Yield"—"Maximum Economic Yield"—it says the same thing: produce at the yield level that lowers **cost per unit** to the point of highest net return or profit per acre.

MEY is not just high yield. Because MEY occurs at relatively high yield levels, there is a tendency to equate MEY with surpluses, and with marketing problems, low prices, and acreage controls. Not fair!

Obviously, if everyone produced at MEY levels on present acreage, surpluses could increase. But the answer is not reduced efficiency. An automobile or TV producer, facing surpluses, would never lower his efficiency so as to produce less.

Creative "agronomics" must never be neglected. There is an ever-expanding need for research and education to develop new discoveries, to teach better practices, to delve into the economics and to seek greater efficiency.

Surely the world can better cope with surpluses than with shortages—whether they be shoes, fuel, medicines or food.

Farm problems are acute and the solutions are evasive. MEY simply seeks the most efficient yield. It neither creates nor cures the world farm crisis. But, whatever the situation with regard to farm program, surplus, price or exports, increasing production efficiency should be an integral part of the solution. Can anyone honestly disagree with that concept?

"When one is not up on something, he is down on it."

—J. Fielding Reed

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