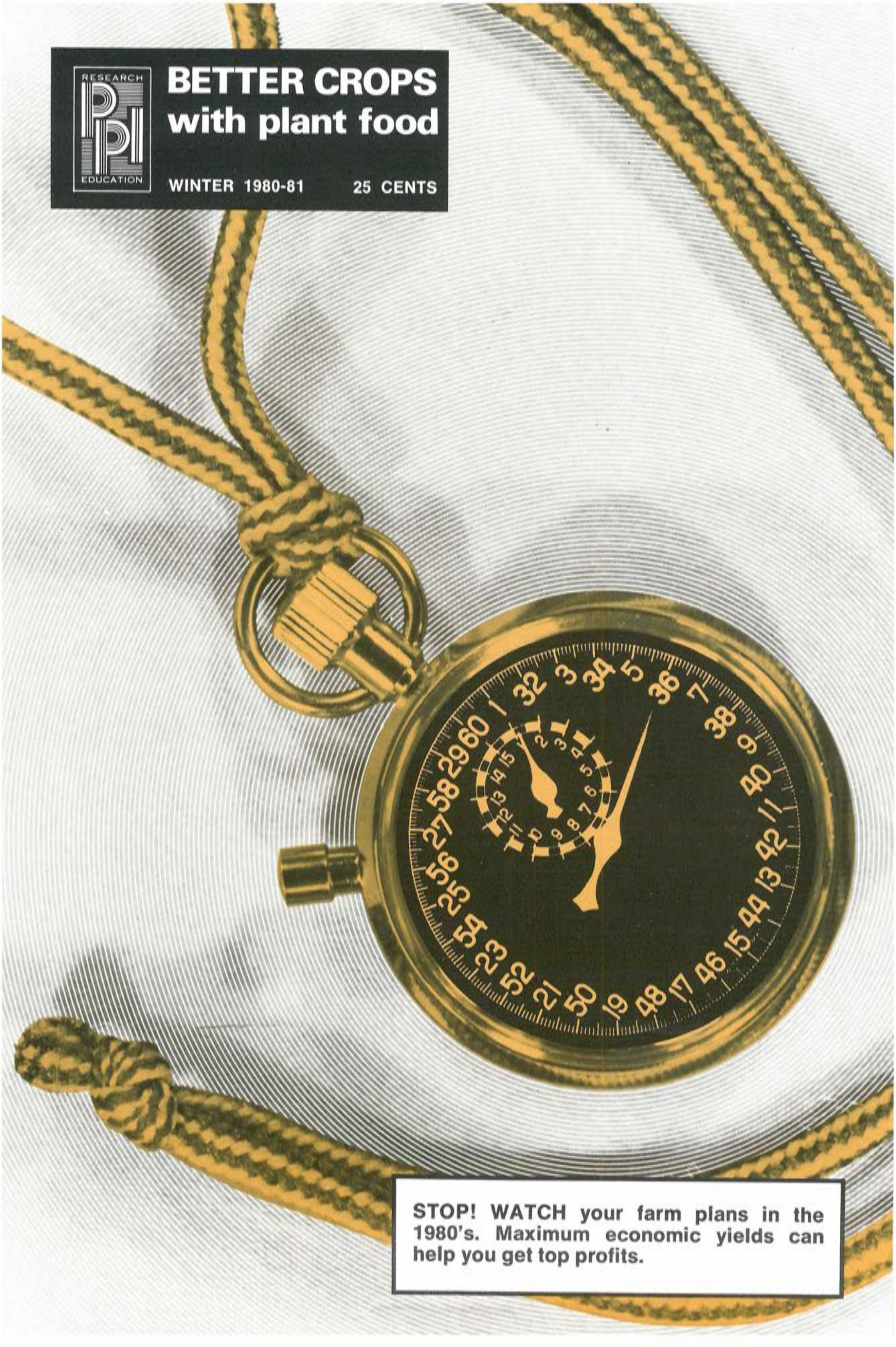
RESEARCH PPI EDUCATION

BETTER CROPS with plant food

WINTER 1980-81 25 CENTS



STOP! WATCH your farm plans in the 1980's. Maximum economic yields can help you get top profits.

BETTER CROPS with plant food

Editors: Bill Agerton & Santford Martin
Assistant Editor: Selma Bushman

Vol. LXIV **WINTER 1980/81**

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Contents

Boron Needs As Related To Maximum Yields

WERNER NELSON
West Lafayette, Indiana

THE NEED for boron (B) has been known for many years and B is recommended for a number of crops in many areas. It is interesting to consider needs for future higher yields.

Higher yields will require more B than average crop yields because:

- —There is a greater amount of plant growth and/or harvested portion.
- —The amount of B taken up per day will be greater.
- —The B concentration in the plant may be higher.
- —Certain reactions in the plant will proceed more rapidly and the quantities of B required should be greater.
- —Higher amounts of other nutrients such as N, P, K or Ca may require a higher quantity of B because of interactions.

For the purpose of this discussion, high yields are considered to be 180+ bu of corn, 60+ bu of soybeans, 8+ tons of alfalfa and 80+ bu of wheat. "High" yields, of course, will vary with the soil and the environment, but almost invariably the attainable yields are higher than commonly thought.

RESEARCH. There is little research with B variables where the top treatments have equaled or exceeded the high yields mentioned. I would appreciate receiving the data of any such experiments.

CORN. Based on an average of 235, 255 and 257 bu of corn, it has been estimated that 400 bu of corn would contain 0.38 lb of B in the grain and 0.10 lb in the stover. Each bu would contain about 0.001 lb of B (R. D. Munson). The effect of genotype on nutrient needs is an age-old question. In Pennsylvania the B content of the ear leaf among five corn hybrids varied from 9.1 to 16.3 ppm.

In Illinois the content of B in 20,000 plants at early tassel was compared at yields of 157 and 68 bu/A. The total contents were 0.081 and 0.035 lb/A, respectively. Boron content was related directly to yield levels. As yields increased 2.3 times, B content increased 2.3 times. Uptake of NPK increased faster than yields, however.

High lysine corn has been found to have higher B requirements. Recommendations at Purdue are 1 lb/A of B broadcast and 0.1 lb/A of B in row fertilizer.

In Nebraska on a sandy soil with 1.1 ppm hot water soluble B, the check yielded 201 bu of corn (4-yr avg.). Added B did not increase yields.

Placement or method of application of boron may make a difference.

In Florida, on a Ruston loamy fine sand, four ¼-lb/A-foliar applications of B at 4, 6, 8 and 10 weeks gave an increase of 19 bu of corn (to 207 bu/A). Soil applied B did not give a significant increase. The next year, 2 lb/A of B soil applied gave a 22 bu increase (to 170 bu) but foliar applied B did not give a response (personal communication, F. M. Rhoads, University of Florida). Further study is needed.

ALFALFA. In New Jersey the B composition of the 1st, 2nd, 3rd and 4th cuttings was 36, 32, 27 and 24 ppm for 8 ton of alfalfa. Was B supply becoming marginal for later cuts? A removal of 0.43 lb of B in 8 ton or 0.054 lb/ton was calculated.

Note in Table 1 the removal of B in the 1979 Pennsylvania five-acre alfalfa yield contest (John Baylor, Pennsylvania, personal communication).

Table 1. Boron removal in alfalfa—5-year yield contest

Number of farmers	Mid-range yield level ton/A	Boron Removal lb/A	Boron Removal lb/ton
3	3.5	0.205	0.0586
18	4.5	0.227	0.0504
20	5.5	0.325	0.0591
18	6.5	0.318	0.0489
6	7.5	0.355	0.0473
2	8.5	0.438	0.0515

SOYBEANS. In Minnesota, seed of many varieties were analyzed and, using 12 percent moisture beans, the range in removal was 0.0013 to 0.0022 lb/bu of B or 0.13 to 0.22 lb of B in 100 bu of soybeans.

On a Sassafras sandy loam in New Jersey with a B soil test of 0.2 lb/A, the check yielded 53.9 bu and 1 lb/A of boron gave 60.2 bu. Two lb of B did not give a further increase (R. L. Flannery, NJ, personal communication).

Note the range in B content of soybean leaves and petioles on five soil types in Indiana, Table 2. A concentration of 16-20 ppm of B is considered deficient.

Table 2. Range of boron content of soybean leaves and petioles on five Indiana soil types

Soil Type	Volk samples: No. of Samples	Volk samples: ppm B Range	Volk samples: ppm B Avg	Wilkinson samples: No. of Samples	Wilkinson samples: ppm B Range	Wilkinson samples: ppm B Avg
Maumee	3	19-38	27	5	30-50	41
Plainfield	2	25-30	28	2	37-52	45
Crosby	3	30-35	33	6	39-70	58
Miami	3	29-51	38	3	50-72	62
Brookston	3	34-36	35	6	30-85	54

FARMER PRACTICES FOR HIGH YIELD CROPS. Herman Warsaw of Saybrook, Illinois, has a corn yield average of 264 bu/A over a 9-year period on his high fertility test area. He used 1.25 lb/A of boron in 1979. Eldon Prybil, who won the Iowa Master Corn Growers Contest in 1979 with 229 bu/A, applied B. Many other examples on corn and other crops could be cited. However, boron is sometimes added on an insurance basis rather than on an actual knowledge of needs.

PUBLISHED UNIVERSITY RECOMMENDATIONS AT HIGH YIELD LEVELS. Specific recommendations for B are few for high yields of corn, soybeans or wheat as have been defined in this writeup. However, there are a number of suggestions for high yield alfalfa. Purdue recommends the equivalent of 2-3 lb/A of boron for 10-ton alfalfa where "B is deficient." The problem, of course, is defining the critical level where "B is deficient" since there are no calibration studies at this yield level. Illinois suggests adding 2 to 3 lb/A/year and Michigan 1 to 2 lb/A/year especially on coarse textured soils of high pH.

In some states, such as New Jersey, recommendations are based on a soil test.

MAXIMUM YIELD RESEARCH ON BORON NEEDED. Maximum yield research is research conducted to obtain maximum yields for the soil and environment under study. This means that the best known technology in all areas of crop production and soil management must be used. Economics is of no concern. The objective is to determine the potential yield for a given situation over a period of years.

Maximum yields will vary among soil types, environments, and years at the same location. Maximum yield will equal maximum potential yield at a given location if all parameters are in place and optimum when that "perfect" year occurs. It may be 300 bu/A of corn at one location and 150 bu at another; 90 bu of soybeans at one or 50 bu at another; 130 bu of wheat at one or 60 bu at another; 12 ton of alfalfa at one and 6 ton at another.

Crop and soil management practices interact and are dependent on each other. The researcher must explore B, lime and fertility interactions with other factors such as population, fertilizer placement, row width, variety, tillage, and soil type. Effects are cumulative and long-term experiments are essential.

Frequent observations and measurements on soils and plants during the growing period are essential in order to help evaluate the changes needed to remove limiting factors for the next season. It is important to involve co-workers from other disciplines in these evaluations. It may take several years to really get the act together to better master the controllable factors.

There are a few boron studies underway. But much of the research on which present recommendations are based was done many years ago with practices and yields not applicable to the needs of the modern, progressive farmer.

Note in Table 3 the effect of yield level on response of alfalfa to a higher pH (R. L. Flannery, NJ, personal communication). With low fertility the response was 0.4 ton but with high fertility it was 2.5 ton. At the higher yield the B need is certainly greater. P was medium high and K medium in the soil.

Table 3. The effect of pH on response to fertilizer

Fertilizer rate lb/A	pH 5.5	pH 7.0	Increase
	ton/A		
0-0-0	3.4	3.8	0.4
0-150-300-3 (B)	5.5	8.0	2.5
Increase for fertilizer	2.1	4.2	

MAXIMUM YIELD RESEARCH PROGRAMS. The number of researchers aiming for maximum yields on such crops as corn, soybeans, wheat and alfalfa has increased greatly during the past few years. Many are adding micronutrients including B, as an "insurance" measure but thus far there is little emphasis on determining actual needs. After the researchers implement top level management, more variables —including boron—will be studied. It is essential that soil and plant analysis be calibrated at maximum yield levels. A crucial question is "what amount of B and/or fertilizer will it take to reach 180+ bu of corn, 60+ bu of soybeans, 80+ bu of wheat or 8+ ton of alfalfa."

LOOKING AHEAD. As more farmers aim for maximum economic yields or top profits per acre, many will add such nutrients as B as an insurance measure. We know that higher yields will require higher amounts of B, whether from the soil or from applied B. The amounts that should be added is a real question. Until the experimental data are available we must rely on judgment and common sense. **The End**

So, You Wanna Make Graphs . . . And Slides

BILL AGERTON
Editor

GRAPHS AREN'T SO DIFFICULT to prepare if you've done your homework . . . even when you want slides of them. Let's look first at preparing graphs. Then we'll tie the two together.

Graphs must communicate your message quickly and effectively. A simply prepared graph showing factual information can help get your point across. Define your units of measurement—example: bushels per acre. Label each axis appropriately and communicate one central theme (Figure 1). Prepare concise headings that tell what

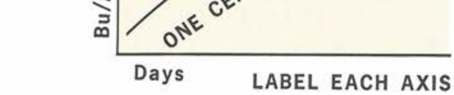


FIGURE 1

your data show. Then assure that data effectively communicate. Sometimes you may use more general axis names. For example, decreasing or increasing may identify an axis on your graph when you merely want to illustrate a concept. Naming specific units becomes unnecessary in the latter case.

Utilize accurate scales to prevent distortion of your data and creation of a credibility problem with your audience. Keep it simple—NOT TOO MUCH ON A GRAPH.

Graphs must be workable in size and format. It is easier to read a horizontal graph, but you must provide enough vertical dimension to create visual impact. Develop your rough on an 8½" x 11" maximum page size. If the graph is to serve as a slide, you may need to make it smaller to maintain a workable size. Type size must be large enough to maintain readability.

It is permissible to break an axis to emphasize a point. But you should still use a uniform scale between points. If you have a series of graphs showing the same type information, use the same scale within the series. This keeps your reader from constantly referring to new measures and scales, thus enhancing communications. Figure 2 illustrates how to break an axis to emphasize a point.

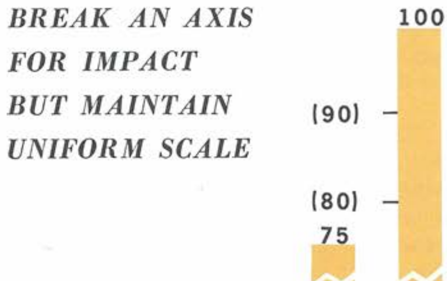


FIGURE 2

Adapted from presentation at PPI staff meeting in East Lansing, Michigan, July 29-30, 1980.

Remember that you should create an accurate representation, because YOU MAY BE COPIED . . . RIGHT OR WRONG! Think of your editor. Your editor may assume that the scales you've indicated are correct and will merely copy what you have prepared. This frequently happens, especially with complex data.

But what about slides? Slides of graphs can make excellent visuals for talks and presentations. And when combined with photographs, tables, line artwork, word slides, or other types of slides, they can create enormous impact.

A 35mm slide (2″ x 2″) utilizes a 2 x 3 ratio (Figure 3) and graphs don't

35mm SLIDE FORMAT

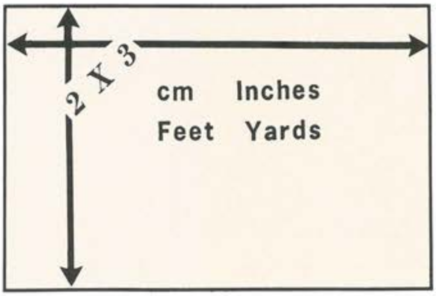


FIGURE 3

always fit. However, if you know what graphs you'll need in slides, it's helpful to prepare the graph for both uses. Printed materials may use slide artwork more readily than is true of the opposite.

Visualize a frame 2 x 3cm, 2 x 3 inches, or 2 x 3 feet in size. Like fertilizer ratios, a 4 x 6 or an 8 x 12 of these units of measurement, respectively, would be the same ratios. There are also numerous 2 x 3 combinations between these dimensions (example: 3 x 4½, 5 x 7½, etc.). Thus, as long as you maintain that ratio, you can proportion your slides to fill the frame and present a visually pleasing image.

Check your work with a slide proportion overlay as indicated in Figure 4

USE SLIDE PROPORTION OVERLAY

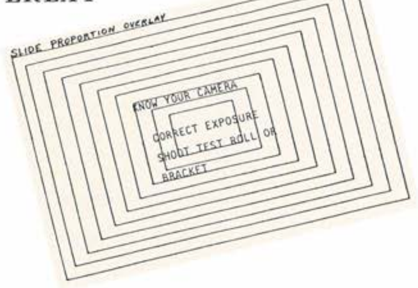


FIGURE 4

and rework your scales and copy to fit this 2 x 3 format. A practical size for the overlay can easily be prepared in an 8½″ x 11″ format. Your copy may not lend itself easily to the 2 x 3 format. It may be too wide or too deep, especially when you have prepared it for printing, using somewhat more natural scales. Yes, slide work may require adjustments to a seemingly less logical scale. Why? If you want to salvage readability, you'll have to compromise on those vertical graphs.

You should have a title for your graph that clearly labels what you are showing. In printed material, this is sometimes left in the text, but in slide presentations, the slide should communicate the idea. When copy won't fit, re-edit and change your headings and copy to make them fit as nearly as possible.

How much copy can you get into a slide and still maintain readability? That's hard to say. Generally, let's assume a 15 x 45 rule of thumb. That's 15 lines in depth equivalent and 45 characters in width equivalent as indicated in Figure 5. As type sizes change,

AMOUNT OF COPY AFFECTS READABILITY

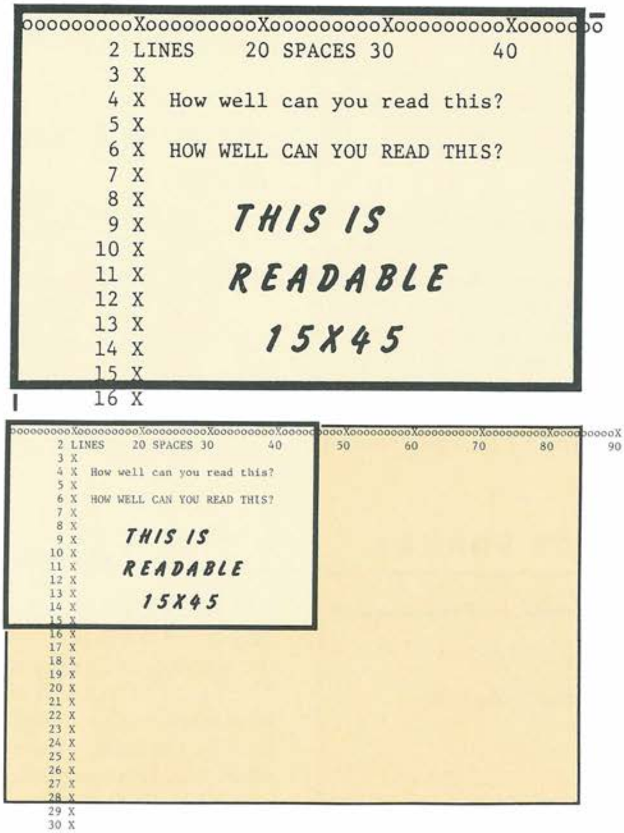


FIGURE 5

proportions still remain unless character size and/or line spacings change. And type styles affect readability. Block type is more readable than a fancy script type. Stay away from condensed type in slide work since it is harder to read. Use regular or expanded type. Proportions will change with expanded type. Your data may require a larger format that will decrease readability. Edit copy to retain readability without losing comprehension. Shorten titles and phrases, abbreviate and eliminate unnecessary words and data. Even this 15 x 45 size is questionable. A smaller format would be better.

PPI staff members have used this rule of thumb in the past: "Type in the finished slide should be readable with the naked eye when the slide is held 18 inches away from the eye." If we prepare a slide using 28 lines and 84 characters, type is extremely small. In fact, the slide will likely flunk both PPI readability tests. It's like putting a typewritten "FOR SALE" sign on your car window and expecting people to read it from a distance. The message is lost.

The 15 x 45 rule is really pushing the limit for highly readable slides. As we decrease the number of lines and the number of characters, we find that readability is greatly increased. And that brings up another point. Filling the frame is important in maintaining readability. On the finished slide, you should have about one-sixteenth inch margin on all sides of the copy. This is more a matter of judgment, however, because you're really achieving balance for a pleasing effect without reducing readability. And your copy may come closer to the sides than top and bottom or vice-versa.

Capital letters can help too in the production of slides. Since we are using a character count rather than compensating for different type styles, our scale will still hold. It is not necessary to count every character in every slide and graph you do unless you're finishing the slide, but it is helpful for you to understand this concept. You can predetermine dimensions for the typed copy and provide a quick check for your work.

Remember that some data may have to be deleted from tables, etc. Too much data in a table may render your slide unreadable. Split your data into two slides if needed to make them comprehensive and readable. You'll keep slides neater and better balanced, too.

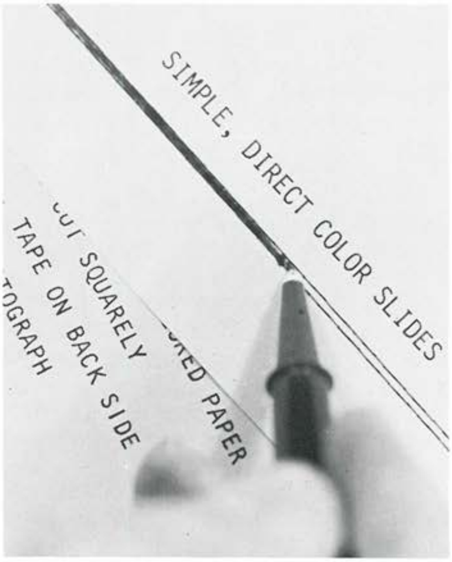
Whether you're preparing graphs, tables or word slides, there are several options for typesetting. You may use a felt tip marker, perhaps on posterboard; you may typewrite the copy on white or colored paper; you may use the varifont machine or some other professional typesetter; or you may use transfer type. Using a professional typesetter is recommended, but not always practical. Many problems can arise unless you communicate well with your typesetter. And cost can be high, too. There are numerous sources of gamma slides. These are slides in which artwork is prepared ahead of time and shot on Kodalith film. Usually, these slides combine white letters on a colored background. Different colors can be added. These are more costly than the slides previously discussed.

A satisfactory copy can be achieved using the typewriter or transfer type. In fact, transfer type comes in different colors and that allows you to achieve more than two colors in your slide.

Prepare a rough draft of your copy so you can proportion according to the 2 x 3 format. Use capital letters to maintain readability. Use the slide proportion overlay to adjust characters and lines. Add or delete lines and spaces to make final adjustments before typing. You may have to re-edit. Type final copy free of smudges.

The resources available to you will determine how you prepare the final artwork. If you have access to a photo copy machine, you may use acetate sheets. Type copy onto white paper using a carbon-ribbon typewriter and photo copy onto a clear acetate sheet. Colored background paper can be placed behind the acetate sheet to add color to the slide.

If this method is not available, you can still add color by typing your copy directly onto colored paper (photo).



To make a simple 4-color slide, type the heading on one color paper, the text on a second color and use a felt-tip marker to produce a color dividing line. Trim carefully along dividing line and join together on backside for ready to shoot copy.

Stay with colors like canary, yellow, light blues, greens or ivory. By using tape on the back side, you can position two or more colors for added effect in your slide. You'll have to check copy to square all of your type.

The simplest way to photograph your artwork is to use a copy table with photo-flood lights balanced for the type of film you are using. An alternative is to shoot the slide outside using natural light. Place a piece of non-glare glass over your copy to hold it in place while photographing. Use a tripod if a copy stand is not available. You may have to construct a board to hold your copy so your camera can be positioned squarely with the copy. If the camera lens is not square with copy, you will distort your type.

Select a daylight film if you are using suitably color-balanced light or if you plan to shoot outside (ASA 25 or ASA 64 slide film). You may have to use a special filter if you are shooting inside with other lights. You will also need a set of close-up lenses on your camera lens unless you have a macro lens. If you are shooting poster-sized artwork, close-up lenses will not be needed; however, typewriter copy will require them.

A +1, +2 and +3 set is inexpensive and will allow you to shoot an 11 x 32 format (from typewriter copy) slide on a 55mm lens. By adding a +7 lens, you'll have a combination to shoot a 5 x 14 format. This will vary from one camera to another. Lenses can be stacked. A set of +1 ,+2 and +3 will suffice for many of your jobs. Use this system as a back-up when you **must have** a few slides very soon.

Check all camera settings to avoid goofs. The wrong ASA setting can cause you to goof a complete roll of film. Other wrong settings can cause similar problems. Set the ASA feature of your camera to match that of your film. Set camera to "Automatic" if you want to use automatic exposure for your slides. If you are shooting slides on the copy table inside, you may need to set the over-exposed feature for one or two f-stops (+1 or +2). This automatically opens your camera lens by the number of f-stops you've set. Overexposure is sometimes necessary when shooting inside on the copy table. You'll have to determine the correct exposure for your camera by shooting a roll on which you bracket exposures. Use an f-stop setting within the exposure range of your film. Your camera should indicate whether you are within that range.

When using manual settings, set your combination of shutter speed and f-stop to allow for the one or two f-stop overexposure your camera needs. Use an f-stop of f/4, f/2.8 or f/1.8 if you are shooting a flat plane surface. If you are shooting 3-dimensional subjects, you'll have to use an f/11, f/16 or f/22 to maintain depth-of-field. Remember that depth-of-field can be improved or extended by using smaller lens openings or by moving the camera further away from the subject. Small subjects can eliminate the latter as an alternative.

If you still have problems, talk with your visual editor (photographer). You and your editor will benefit from your increased knowledge of preparing graphs and slides. **The End**

Delta Cotton Benefits from P and K

WILLIAM O. THOM, Former Research Agronomist, Delta Branch Experiment Station, Mississippi Agricultural and Forestry Experiment Station. Now Agronomist, University of Kentucky.

PHOSPHORUS AND POTASSIUM have become key elements in producing maximum cotton yields in the Mississippi Delta.

In the past, soils of this region have produced high cotton yields with only the use of nitrogen fertilizers. Recent soil test summaries have shown the percentage of soils in the Delta needing P and K has increased from 24 to 28 percent and from 32 to 48 percent, respectively.

P and K fertilization research was begun in 1976 at one location on a silt loam soil. In 1978 additional tests were initiated at four locations to study more soil types and involve other cotton varieties and farmer management systems.

THREE YEARS OF DATA (Table 1) from a Dundee-Clack silt loam in the central Delta indicate a response to phosphate was obtained without potash. Potash increased yields at 0 and 30 lb levels of phosphate ($p < 0.05$).

Yield increases from potash decreased with increasing phosphate additions. Soil tests were high in K (240-360 lb/A) and medium in P (36 to 72 lb/A) when the study began. Check plots remained in those ranges during the study.

Table 1. Lint cotton yields on a Dundee-Clack soil following P and K addition.

Applied P_2O_5	Applied K_2O	1976	1977	1978	3 yr. mean
lb/A/yr			lint cotton lb/A		
0	0	437	666	423	509
0	60	481	743	461	562
0	120	499	754	471	575
30	0	497	680	432	536
30	60	503	731	489	574
30	120	522	752	481	585
60	0	498	740	471	570
60	60	521	784	422	576
60	120	519	754	482	585
LSD	0.05	47	86	ns	37

90 lb/A of nitrogen applied preplant

Table 2. Lint cotton yields at four locations following P and K additions, 1978.

Applied P_2O_5	K_2O	Dundee-Clack silt loam	Commerce silt loam	Soil Type Dundee fine silt loam	Forestdale silt loam	Mean
lb/A		lint cotton lb/A				
0	0	423	557	779	533	573
0	60	461	581	905	576	606
0	120	471	635	958	681	686
30	0	432	558	834	557	595
30	60	489	597	826	620	633
30	120	481	679	982	590	684
60	0	471	651	870	565	639
60	60	422	595	875	561	614
60	120	482	655	978	690	701
	LSD, 0.05	ns	95	129	—	—
	LSD, 0.01	ns	—	—	94	67
	Variety	Stoneville 213	DPL55	Stoneville 213	DPL16	

90 lb/A of nitrogen applied preplant.

In 1978 the expanded tests **(Table 2)** on four soil types followed the same yield trends as the single location did. The mean yield increases from 60 lb/A phosphate without added potash were significant ($p < 0.05$).

Mean yield increases for 120 lb potash at all levels of phosphate were also significant ($p < 0.05$). Soil tests in all plots were in the high range for K before the study was started. The P soil tests were in the high and very high ranges.

THE MOST EVIDENT FACT is that yield increases for the second increment of potash (120 lb/A K_2O) were much larger than the first increment of potash (60 lb/A K_2O) at all levels of phosphate treatment.

Three varieties of cotton were represented at the four locations, indicating the yield increases were related more to the fertilizer applications than variety.

Potash is needed for cotton on sandy loam and silt loam soils in the Mississippi Delta. Phosphate is normally not needed, but yield increases without added potash raise several questions of why these yield increases are possible.

On the other hand, the second increment of potash increased yields more than the first increment at all phosphate rates. This suggests an influence of potash on one or more of several other factors, including gin turnout (%), micronaire, fiber elongation, or improvement of disease tolerance of the plants.

THE CONSISTENT RESPONSE to potash additions at all phosphate rates with the soil test levels in the high range indicates the need for potash fertilization of cotton.

Research to improve soil test calibrations for potassium in the Delta is needed. Good soil test calibration is a key element in making soil test recommendations for efficient fertilizer use. **The End**

(This research was supported in part by International Minerals and Chemical Corporation.)

Salinity Damage to Rice Seedlings . . .

J. T. GILMOUR
University of Arkansas

EXCESS SOLUBLE SALTS are often suspected as the cause of rice seedling damage and stand losses in Arkansas.

In such cases, blame is usually attached to over-use of potassium fertilizer and/or poor quality irrigation water in combination with weather patterns or soil conditions which cause soil water to move and concentrate salt in the root zone.

In 1976, we initiated a research program to verify that damage was due to soluble salt and to determine if over use of potassium (KCl) fertilizer was a likely contributor to the problem.

Figure 1 presents the results of our 1976 survey, where 130 samples of Crowley silt loam and associated soils from suspect fields were assayed for salinity. The measure of salinity, EC_e (electrical conductivity of the saturation extract in mmhos/cm) was above 4 mmhos/cm in more than 30 percent of the fields.

Since this level of soluble salt is known to cause damage to rice, we then had evidence that salinity was a real problem facing the rice producer.

In 1977, we continued surveying fields with an enlarged goal—to reaffirm our 1976 results and to determine if chloride was a major contributor to the observed EC_e.

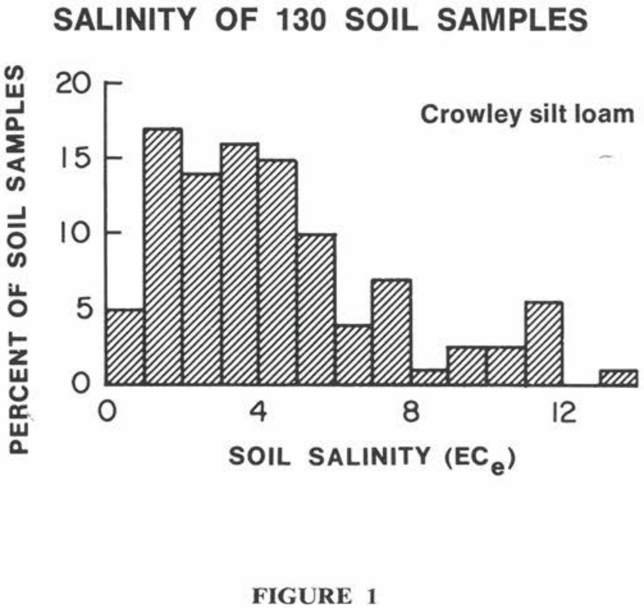


FIGURE 1

Again, we found that a substantial portion (nearly 50 percent) of the soil samples collected had an EC_e in excess of 4 mmhos/cm. **Table 1** gives a summary of the results of the 1977 survey which pertains to the estimate of the contribution of chloride to these EC_e's.

TABLE 1

Mean Soil Chloride (ppm)	Mean Soil EC_e (mmhos/cm)	Number of Samples	Chloride Contribution to EC_e (%)
170	5.9	20	15
45	7.8	11	3

TWO GROUPS OF SAMPLES were found. One group had high chloride levels (170 ppm) in relation to EC_e. The second group had low chloride levels (45 ppm) with respect to EC_e.

While within both these groups EC_e and chloride were significantly correlated, **in neither group was chloride a major contributor to EC_e.** Only 15 percent of the EC_e in the high chloride group was attributable to chloride salts, while only 3 percent of the EC_e was due to chloride salts in the low group.

These results indicated that over-use of KCl fertilizer and/or use of irrigation water containing excessive chloride concentrations were not the primary cause of the observed salinity.

In order to pursue our hypothesis that KCl fertilizer was not the primary source of the salinity and to determine which other anions might be involved, we initiated growth chamber studies in 1978.

Table 2 presents the results of a typical experiment where Starbonnet rice seedling survival was determined in a Crowley silt loam soil amended with various rates of KCl, KNO_3, and K_2SO_4.

TABLE 2

Seedling Survival (%)	Soil Chloride (ppm)	Soil Nitrate* (ppm)	Soil Sulfate* (ppm)
75	860	1,120	>4,400
50	1,520	1,980	—
25	2,190	2,600	—

*Added as K salts

These results showed (1) soil chloride levels higher than have been recorded in the field were necessary to damage rice, (2) sensitivity of rice seedlings to nitrate was similar to that of chloride, and (3) sensitivity of rice seedlings to sulfate was much lower.

THE GROWTH CHAMBER STUDIES supported the hypothesis that chloride was not the main cause of the seedling damage, identified nitrate as a potential source of salinity, and suggested that sulfate as probably not causing the problem. In addition, these investigations emphasized that **K fertilizer applied at normal rates would not result in salinity damage to rice seedlings unless concentrated several-fold.**

In 1979 and 1980, we initiated field rate studies at the Rice Research and Extension Center near Stuttgart. In 1979, the Crowley silt loam soil was amended with up to 672 kg/ha K as KCl, K_2SO_4, or KH_2PO_4, while in 1980 only KCl and K_2SO_4 were evaluated.

The higher rates are several times the annual addition applied by a typical rice producer and were soil incorporated just prior to seeding Starbonnet rice. In 1979, some damage to rice (leaf tip burn) was found at the highest KCl rates, while no seedling damage due to KCl was found in 1980. No seedling damage from K_2SO_4 or KH_2PO_4 was observed.

These results were in agreement with our growth chamber studies which showed more than triple the highest chloride field rate would be required for 25 percent damage. A rainy period following planting both years possibly reduced any potential salinity effect.

RICE YIELDS IN THE FIELD STUDY were not affected by KCl additions in 1979 and were actually increased at high rates of KCl in 1980. This yield response did not appear to be due to K, however, as K_2SO_4 at equivalent rates of K to KCl did not increase yields in 1980 (data not shown).

Apparently, excessive rates of fertilizer alone should not be expected to damage rice seedlings unless unique weather patterns concentrate the salt in the rootzone, a situation which did not occur either year of our study.

The results of field surveys, growth chamber investigations and field experiments established that salinity damage to rice seedlings is occurring in Arkansas and that KCl fertilizer does not appear to be the primary cause.

Future studies will define the role of nitrate and attempt to describe the phenomena associated with the concentration of the soluble salt in the rootzone of the rice seedlings. **The End**

The Cutting Edge

D. W. Dibb, Columbia, MO

COST INCREASES in central Illinois during the 1970's as described by the University of Illinois Farm Business and Farm Management Records Program illustrate the urgency with which farmers face the challenge of increasing their yields. If USDA data for Illinois on yields and prices received by farmers are included, the following trends emerge:

1970's trends — Illinois

	Corn	Soybeans
Yield increase/A	3.2 bu/yr	0.63 bu/yr
Price increase/bu	11.35¢/bu	39.5¢/bu
Production cost increase/A	$28.35/A/yr	$22.88/A/yr

Projecting these 1970's trend lines through the 1980's, production costs will almost double to $637/A for corn and $517/A for soybeans in 1989 — compared with $353/A and $288/A in 1979.

1989 Production costs — Projected from 1970's trends

	Corn	Soybeans
Cost of production $/A	$637.00	$517.00
Value/bu	$ 3.77	$ 11.13
Break-even yield bu/A	169	47

HOPEFULLY THE FARMER will continue to do a better job of marketing. Year-to-year price fluctuation will affect the results, but using the trend line price, the average farmer will have to increase soybean yields twice as fast, and corn yields 50% again as fast as he was able to during the 70's in Illinois, just to break even.

Much has been written about the increasing world population, increasing world food needs, and the importance of U. S. farm productivity to U. S. balance of trade. These concerns will undoubtedly intensify in the 80's. But the most imminent and **urgent** concern of the U. S. farmer will continue to be that of meeting higher production costs with higher yields. The key to survival in the business of farming as in other businesses is still through increased productivity.

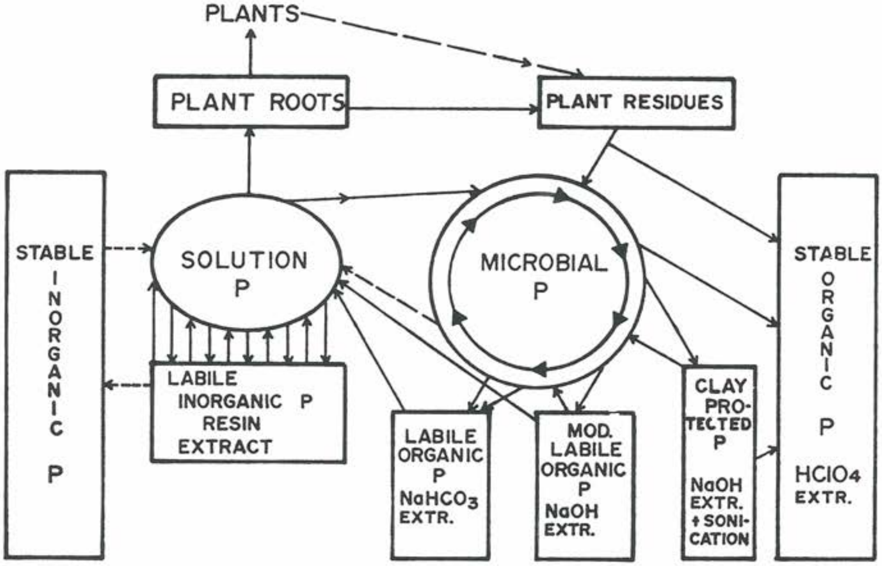


Figure 1: A simplified picture of the phosphorus cycle in soils showing the type of interchange of solution, inorganic, organic and microbial P forms.

The Importance of P Cycling and Organic P in Soils

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ORGANIC PHOSPHATE (P) content in the surface horizons of cultivated Chernozemic soils in Western Canada range from 25 to 55% of the total P content, with microbial P accounting for upwards of 10% of the organic P content.

Organic P contents fluctuate with season especially under favorable moisture conditions. **Table 1** shows an extreme example of the fluctuation of organic P found in two irrigated alfalfa fields in S. Alberta, where, in each of the five fields examined, organic P content decreased during crop growth and development and increased during crop dormancy.

Earlier work in the Northern Great Plains showed the amount of P removed by 24 to 41 years of cropping could be accounted for by an average 35% reduction found in the soil organic P contents, in contrast to soil inorganic P which was found to be relatively unchanged.

STUDIES ON NUTRIENT CYCLING in grasslands, as part of the Canadian and United States International Biological Programs (1967-74), provided a much needed stimulus to examining the movement of P in the soil-plant system. As a result, our understanding of P cycling has increased and can be depicted in simplified form **(Fig. 1).**

Soil solution P is shown to be in equilibrium with a quantity of labile inorganic P such that in any one soil the ratio of **labile inorganic P to solution P** maintains a constant ratio over the normal range of P concentration found in cultivated soils. This ratio is called the capacity factor. Size of the capacity factor depends on the physical and chemical properties of the adsorbing colloids and has been measured from less than 10 to greater than 1,000.

Solution P will be taken up by plant roots depending on root distribution in the soil, soil moisture, soil temperature, available soil nitrogen, etc. Similarly, some of the solution P will be immobilized by the soil microbial population and will be redistributed throughout the soil as the microbial population dies through lack of an energy substrate, lack of moisture, amoebal grazing or nematode activity, etc.

Within the microbial cell P, exists as a wide variety of compounds, principally RNA (30-50%), acid soluble inorganic and organic P (15-20%), phospholipids (< 10%) and DNA (5 to 10%).

If the microbial cell wall is ruptured or lysed, all these compounds will be released to the soil solution to react with both inorganic and organic soil components to form a host of compounds of differing susceptibility to mineralization.

The rate of mineralization depends largely on phosphatase activity which, in turn, can be controlled by solution P concentration. Root residues and exudates stimulate microbial activity, simultaneously immobilizing and mineralizing P.

TO EMPHASIZE THE CENTRAL ROLE of the microbial population in P cycling, **Figure 1** depicts microbial activity as a "wheel" which rotates in the soil picking up solution P, forming organic P compounds of varying stability, some of which return to solution through both enzymatic and/or chemical mineralization.

Should the "wheel" be stopped or slowed down through partial soil sterilization, by environmental phenomena such as freezing and thawing of the soil, or by artificial means, the supply of P to plants will be limited to the quantity of labile inorganic P.

If the "wheel" is operating, then the plant has a much larger quantity of available P as solution P is constantly being recharged by mineralization of

Table 1. Seasonal Patterns of Total Organic P in the Top Unfertilized 0-15 cm Layer of Two Irrigated Alfalfa Fields in S. Alberta.

		Organic P-ppm in Soil						
	Year	Apr	May	June	July	Aug	Sept	Oct
Site 1	1	88	51	43	43	56	72	73
	2	242	153	146	134	116	122	138
	3	213						
Site 2	1	102	73	56	36	20	46	82
	2	226	158	130	110	100	120	146
	3	206						

organic P as well as by equilibrium with the labile inorganic P.

The fact that this type of redistribution of P can occur helps explain earlier data on loss of organic P in the Northern Great Plains' soils and also has practical implication in modern agriculture. Most soil tests for available soil P, such as the Olsen bicarbonate extraction procedure, measure a proportion of the labile inorganic P pool only and relate this to plant P uptake and yield.

It should be noted that significant amounts of organic P can be extracted by the Olsen method. However, the organic P component is not normally included in the determination of P in the extract because it is deliberately removed by adsorption on charcoal or by some other means.

THE STANDARD OLSEN TEST has proved to be a good guide for estimating fertilizer P requirements in cultivated Chernozemic soils of western Canada.

On the other hand, it has not been reliable for predicting P requirements for tame pasture or native range where substantial quantities of organic P can be extracted but not usually included in the P measurement.

If the organic P fraction is determined along with the bicarbonate extractable inorganic P, the Olsen procedure becomes suitable for assessing the available P status of soils supporting either domestic or native forage crops.

Examples of this can be seen in **Table 2** of changes in both liable inorganic and organic P in a native grassland with season. This soil would be assessed as very deficient in P by the Olsen soil test method, i.e., the bicarbonate extraction which measures only inorganic P. However, it is clear from the data that it contains large quantities of easily extractable organic P.

Table 2. Bicarbonate Extractable P Values in the Top 0-15 cm Layer of a native Grassland Soil During One Season.

Date	Bicarbonate Extractable P Inorganic P	Organic P
	ppm in Soil	
May 19	2.0	10.5
June 20	2.1	9.7
July 24	1.2	28.5
August 22	2.1	8.0
September 20	1.3	12.5
November 5	2.7	12.5
May 8	1.8	6.1

Field studies showed that yields obtained from this native grassland soil could be increased by adding N and extra irrigation water but did not respond to extra P fertilizer.

Similar results **(Table 3)** have been obtained with irrigated alfalfa tests, carried out by the University of Saskatchewan in 1976 and 1977, in which the regular bicarbonate test predicted that yield increases should be obtained

Table 3. The Effect of Added P Fertilizer on Yield and Composition of Irrigated Alfalfa in Relation to Bicarbonate Extractable P. (Data From University of Saskatchewan Plots at Outlook, Sask.)

Year	P_2O_5 Lb/A	Yield Lb/A	% P in Alfalfa	Bicarbonate Extractable P ppm in soil Inorganic	Organic[1]
1976	0	7,066	0.23	2.8[2]	10.6[2]
	100	7,180	0.23	10.1	10.8
1977	0	9,296	0.22	2.8[2]	3.5[2]
	75	10,164	0.29	9.0	3.7

[1]Organic P usually removed and not measured.

[2]Values obtained at beginning of growing season.

from applied P. None were obtained in the first year of the trial when the soil contained appreciable quantities of bicarbonate extractable organic P. In the second year a response to applied P was obtained.

Measurement of both labile inorganic and labile organic P gave a much better prediction of yield responses to applied P.

ONGOING LABORATORY STUDIES using isotopes to label various soil P pools have emphasized the dynamic nature of P cycling by showing continued interchange between labile inorganic, organic and microbial P in soils.

Significant amounts of organic P in soils are available to plants and P in this form can be important as a supplier of crop P under specific environmental conditions.

We are attempting to understand the complete P cycle under temperate and tropical environments so that we will be able to utilize our P resources to the maximum. **The End**

Fertilizing Alfalfa To Get TOP YIELD

ROBERT D. MUNSON
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ALFALFA RESPONDS like a champ to liming, fertilization, and top cutting or grazing on sites with proper drainage and soil pH.

Then how does one pick the best fertilizer program for high quality, top-profit yields?

If we seriously look for data on the art of fertilizing alfalfa for top yields, we discover such data are hard to find.

WHAT IS THE nutrient content of top yield alfalfa? We are not overburdened with plant tests from high yielding alfalfa fields.

TABLE 1 shows the nutrients contained in each ton of 12% moisture hay from several states and a province.

To convert these average nutrient levels to the amount in 10 tons of hay, simply move the decimal point one place to the right.

It is interesting to note nutrient breakdown in the hay—78% mineral nutrients, 21% secondary elements (Ca, Mg, S), 0.3% micronutrients.

Alfalfa demands plenty of nutrients. A unique feature is alfalfa's capacity to fix much of its own nitrogen if other essential elements are provided. Important in an energy-conscious day.

LIME SOILS to a pH that is up in the range of 6.8-7.0, if you expect top alfalfa yields.

Iowa data indicate near 7.0 is optimum. Microbial activity seems to increase with soil pH. This releases nutrients from soil organic matter. With good soil moisture and enough other nutrients, you have ideal conditions for nitrogen fixation by the Rhizobia associated with root nodulation.

Apply Ag-lime well ahead of seeding to allow pH adjustment. Soil pH doesn't adjust rapidly if coarse Ag-lime is used and/or dry weather occurs after liming.

Three factors are important to lime adjustment: soil moisture, high quality Ag-lime in terms of fineness and calcium carbonate equivalent, and proper mixing in plow layer.

Deeper plowing demands more Ag-lime, which most states now recommend.

FERTILIZING ALFALFA and managing it for top production will put your farmers in a select group.

Even in good dairy areas, about one field in ten is being fertilized and managed for top yields.

Matching soil and top alfalfa yield with a fertilizer program can be very challenging.

Soil testing is the starting point for fertilization. The wise grower will take soil samples and know the drainage, the low organic matter areas, and other problems in his fields so they can be spot treated to smooth out each field.

That may take some special fertilizer

Table 1. Pounds of Nutrient Per Ton of Alfalfa Hay for a Range of yields.*

	Yield* tons/A	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Cu	Zn	Mn	B	Mo
WI	3.5	—	11.3	39.1	33.1	6.0	—	0.23	0.009	0.035	0.132	0.018	0.002
Manitoba	4.5	61.6	10.1	52.8	—	—	4.5	—	0.014	—	—	—	0.006
MN	5.0	—	12.1	47.7	37.0	6.5	—	0.22	0.008	0.058	0.076	0.072	—
WI	5.0	59.1	10.5	57.7	23.9	6.7	3.9	0.25	0.019	0.044	0.090	0.040	—
MN	5.4	—	17.3	52.2	21.8	5.3	6.1	—	0.009	0.054	0.098	0.062	0.022
NE	6.0	58.1	9.3	73.9	26.4	7.2	—	—	—	—	—	—	—
ND	6.2	59.8	8.9	61.2	23.8	4.0	—	0.17	0.005	0.02	0.1	0.05	—
WI	6.3	—	12.7	72.4	22.5	4.0	—	0.36	0.009	0.026	0.114	0.035	—
WI	6.5	57.9	11.3	72.6	18.1	4.2	6.26	0.16	0.021	0.032	0.104	—	—
NJ	8.0	51.7	11.8	49.9	18.8	4.4	3.3	0.21	0.014	0.038	0.056	0.052	0.006
MI	8.1	56.4	13.4	47.6	—	5.6	—	—	—	0.05	—	0.06	—
IL	8.4	—	9.5	39.1	25.9	5.5	—	—	—	0.035	0.114	0.079	—
IN	9.2	—	12.9	75.5	24.1	3.2	—	0.84	0.009	0.044	0.135	0.044	—
IL	9.3	—	8.3	38.0	24.3	5.5	—	—	—	0.035	0.106	0.070	—
KS	10.8	60.6	12.4	53.1	25.0	5.3	5.0	0.32	0.01	0.04	0.1	0.05	—
Avg.	**6.8**	**58.2**	**11.4**	**55.5**	**25.0**	**5.2**	**4.8**	**0.31**	**0.012**	**0.039**	**0.102**	**0.053**	**0.009**

*Based on 12% moisture hay.

mixtures, followed by periodic soil tests to tell if the levels are being maintained, building, or declining.

Recommendations are often broken into (1) fertilizer applied before or at seeding plus (2) fertilizer topdressed annually after establishment.

A good fertilizer program should give the grower a top-profit, worry-free production program: High yields. Optimum nitrogen fixation. Quality feed. Even residual nitrogen for the corn crop to follow.

Let's look at current recommendations in some Midwest states:

MINNESOTA. Some good research has been done. **TABLES 2** and **3** show these recommendations.

It is considered more efficient to plow down pre-seed fertilizer before preparing seedbed—especially in drier areas to insure maximum uptake.

Band seeding is an efficient way to apply nutrients at seeding time.

Table 2. Amounts of Phosphate and Potash to Apply at or Before Seeding Based on P and K and Subsoil Soil Test Levels—Minnesota

Soil Test		P_2O_5 and/or K_2O to apply — lb/A		
		Relative subsoil P or K level		
		LOW	MEDIUM	HIGH
P	K	P_2O_5 K_2O	P_2O_5 K_2O	P_2O_5 K_2O
lb/A				
0 - 10	0 - 75	100 + 360	80 + 240	60 + 120
11 - 20	76 - 125	80 + 240	60 + 180	40 + 90
21 - 30	126 - 175	40 + 180	20 + 120	0 + 60
over 30	176 - 225	0 + 120	0 + 90	0 + 40
	over 225	0 + 0	0 + 0	0 + 0

Table 3. Amounts of Phosphate and Potash to Topdress Annually for Alfalfa Based on Soil tests and Soil Texture or Relative Availability—Minnesota.

Soil Test		P_2O_5 and/or K_2O to topdress annually—lb/A	
		Fine Textured Soils	Coarse Textured Soils
P	K	P_2O_5 K_2O	P_2O_5 K_2O
lb/A			
0 - 10	0 - 100	60 + 150	60 + 180
11 - 20	101 - 200	40 + 90	40 + 120
21 - 30	201 - 300	30 + 30	30 + 60
over 30	over 300	0 + 0	0 + 0

Boron (B) and sulfur (S) are widely recommended in Minnesota, especially on the sandier soils above the Mississippi River. The sulfur soil test is quite accurate. And boron deficiency is common, readily identified by the boron test.

Generally, these recommendations should lead to 5 or 6+ tons of alfalfa hay, and even more with tighter management.

WISCONSIN. They consider 5-6.25 tons alfalfa per acre tops on their best soils under top management.

Phosphorus (P), potassium (K), sulfur (S), and boron (B) are most often deficient in Wisconsin's alfalfa soils.

TABLES 4 and **5** give their corrective and maintenance rates for potash (K_2O) and phosphate (P_2O_5). Top management recently got profitable responses to potash topdressed on soils testing 330 lb K.

As in Minnesota, the sulfur soil test seems quite accurate. Any soil S value below 20 would be considered low.

Usually 25 to 50 lb/A S should be incorporated at seeding, followed by 15-25 lb S application annually.

When boron deficiency occurs during dry weather or the soil test is less than 2 lb/A B, apply 2-4 lb/A B once in the rotation. Preferably the first year of alfalfa.

On sandy soils, apply 0.5-1 lb/A B annually with topdressing.

IOWA. Lime to pH 6.9-7.0 at least 6 weeks in advance. Fertilize according to soil test before seeding, as shown here:

Soil test	P_2O_5 (lb/A)	K_2O (lb/A)
Very low	80	170
Low	70	160
Low medium	60	130
Medium	50	100
High	30	80
Very high	0	0

Table 4. Corrective Amount of Phosphate and Potash to Apply Prior to Alfalfa Seeding Based on Superior Soils and Management and Soil Tests—Wisconsin

SOIL TEST lb/A				
P	K	P_2O_5		K_2O
			lb/A	
0 - 10	0 - 100	90	+	240
11 - 20	101 - 140	60	+	180
21 - 40	141 - 180	30	+	120
41 - 100	181 - 240	0	+	60
		0	+	0
over 100	over 400	0	+	0

These rates are based on removal of alfalfa and oats the seeding year, plus maintaining a high soil test or raising the test to a high level.

Topdress annually per acre—half applied after first cutting, half after third cutting — to get the following yields:

6 ton yield — 80 lb P_2O_5, 300 lb K_2O

8 ton yield — 100 lb P_2O_5, 400 lb K_2O

NORTH DAKOTA. They adjust recommendations with soil test values and yield goals. After mineral nutrition, water will be the most limiting factor in many areas. **TABLE 6** shows their phosphate and potash topdress recommendations.

OHIO. Their recommendation system integrates (1) the soil test, (2) amount of fertilizer to change the added test, (3) efficiency with which crops can recover added nutrients, (4) crop removal associated with yield goals.

TABLE 7 shows their annual recommendations for phosphate (P_2O_5) and potash (K_2O) for 6 and 8 tons of alfalfa. Note higher potash rates on higher cation exchange capacity soils (C.E.C.)

Table 5. Maintenance Rates of Phosphate & Potash to Topdress Annually—Wisconsin

SOIL TEST		P_2O_5 and/or K_2O to topdress annually		
P	K	P_2O_5		K_2O
lb/A		lb/A		
0 - 45	0 - 300	60	+	240
0 - 45	301 - 400	60	+	180
0 - 45	over 400	60	+	0
over 45	over 400	0	+	0

Table 6. RECOMMENDATIONS*

Alfalfa Yield Goal	P Soil Test Rating					K Soil Test Rating				
	VL	L	M	H	VH	VL	L	M	H	VH
tons/A	P_2O_5 — lb/A					K_2O — lb/A				
5	75	50	40	0	0	150	130	100	50	0
6	90	65	50	20	0	180	160	130	60	0
7	105	80	60	30	0	210	180	140	70	0
8	120	95	70	40	0	240	210	160	80	0
9	135	110	80	50	0	270	240	190	90	0

*Apply annually, preferably after the first cutting.

Table 7. Annual P_2O_5 and K_2O Recommendations for 6 and 8 Ton Yields—Ohio

P Soil Test	P_2O_5 Recommendation Alfalfa Yield Goal—T/A		K Soil Test	K_2O Recommendations Alfalfa Yield Goal—T/A					
	6.0	8.0		6.0			8.0		
				C.E.C. 10	20	30	C.E.C. 10	20	30
lb/A	lb/A		lb/A	lb/A			lb/A		
5	135	150	50	450	470	490	570	590	610
35	105	130	250	370	390	410	490	510	530
60 - 90	80	105	350	360	360	370	480	480	490
			550	290	310	330	410	430	450

Ohio has reported manganese and boron deficiencies. And recommends 1-2 lb/A MN and/or 2.5-3.5 lb/A B on problem soils.

Table 8.

Soil Test Level	K Soil Test	P_2O_5*	K_2O*
		lb/A	
Very low	0 - 80	230	600
Low	81 - 150	190	530
Medium	151 - 210	150	490
High	211 - 300	110	380
Very High	301+	40	300

*Assumes removal is directly proportional to yield with no change in rate of soil release.

INDIANA. Lime for 6.7-7.0 pH at least 6 months ahead of seeding.

In **TABLE 8,** they recommend fertilizing according to soil test before seeding.

Growers shooting for 10-ton yield should apply 150 lb P_2O_5 and 600 lb/A K_2O, split after the first and third cuttings.

They recommend 20 to 30 lb/A borax when boron is deficient.

A 10-TON YIELD starts with a single ton which, we determined, contains 11.4 lb P_2O_5, 56 lb K_2O, 25 lb Ca, 5.2 lb Mg, and 4.8 lb S plus needed micronutrients.

So, if we expect to grow 10 tons of hay, the crop must somehow contain roughly **114 lb P_2O_5, 560 K_2O, 250 Ca, 52 Mg, 48 S, 3.1 Fe, 0.12 Cu, 0.4 Zn, 1 Mn., 0.5 B, 0.9 Mo.**

And the Rhizobia are going to have to fix about 580 lb/A N. To do that, adequate P, K, Ca, Mg, S, B, Co (cobalt) and Mo (molybdenum) must be present with plenty of moisture in a well aerated soil.

Applying fertilizer to alfalfa causes it to better exploit the elements that are present.

Kentucky, for example, applied 150 lb/A K_2O yearly for 6 years to supply alfalfa with 900 lb of K_2O. But the alfalfa removed 2,275 lb K_2O.

The K soil test rose from 240 to 260, indicating maintenance in the surface soil. The crop averaged 6.48 tons hay over the 6 years.

The check plot's K soil test dropped about 100 lb/A, indicating that soil had a good capacity to supply K. Many soils would drop more rapidly because of relatively low supplying power.

For phosphorus, the soil test of the untreated plots dropped from 55 to 21, while the 90 lb P_2O_5 treatment plot increased from 55 to 97 after 6 years, maintaining a 6.23 ton average yield.

REMEMBER SULFUR. It can be low on the eroded hillsides low in organic matter. Special treatment of these eroded sites can pay dividends.

Minnesota scientists, led by Dr. A. C. Caldwell, got these results on a low S sandy loam soil in the north central part of their state:

S rate	Alfalfa—3 cuts—12% moisture
lb/A	Tons/A
0	2.04
50	4.91

Wisconsin has gotten similar results from S in west central areas on silt loam soils.

In 1978, the north central states have averaged these yields, tons/A: **Illinois, 3.5; Indiana, 3.2; Iowa 4.0; Kansas, 2.8; Kentucky, 3.0; Michigan, 2.9; Minnesota, 3.4; Missouri, 2.7; Nebraska, 3.2; North Dakota, 2.10; Ohio, 3.20; South Dakota, 2.40; Wisconsin, 3.10.**

Not many have been thinking about fertilizing alfalfa for top yields. What about your area?

Minnesota and Iowa researchers have hit over 8 tons/A dry matter. Michigan's Dr. Tesar has 6 year averages of 8 tons/A. That's exciting.

And it takes fertilizer and top management to do it—in Michigan or anywhere else. What about you? **The End**

Soils Rested for 2,000 Years Are Still Infertile

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WILL RESTING an infertile, subtropical soil make it fertile? The sandy, coastal plain soils between the Belize River and the Caribbean Sea have been rested for at least 2,000 years, and they are still infertile.

The Mayan empire intensively farmed the alluvial clay of the Belize River Valley and left their stone hoes and drainage grids behind. But on the sandy, coastal soils only singly flaked spear points of the pre-Mayan hunters are found.

The natural vegetation of the coastal plain is a low-growing sedge and scattered small trees—pines, palms and an occasional oak or cashew tree—all less than six inches in diameter.

There are almost no grasses and when the ground is first cultivated few weeds appear, for there is no seed in the soil.

Figure 1. Can you detect a fertilizer response? The sorghum in this picture was planted on January 13 and photographed on March 13. The plants in the foreground received no fertilizer, whereas those in the background received 86 pounds of N, 94 pounds of P_2O_5 and 49 pounds of K_20, plus micronutrients. No weed control was applied to this virgin soil, for it is so naturally infertile that almost no weed seed is present.

This area is near the international airport in Belize. With the aid of a complete fertilizer program, successful crops are being grown for United States plant breeders in the winter.

HOW DID an Indiana-based cooperative get involved in growing crops in Belize? The soybean breeding program at FFR Cooperative initially attempted winter growouts in greenhouses at our cooperative headquarters in Lafayette, Indiana.

But high operating costs (mainly heat), running up to $400,000 on a per acre basis, forced us to look for alternatives to this method. The breeding program had also had winter nursery work done in Hawaii, Puerto Rico and Brazil, with mixed success.

In the winter of 1974-75 we wanted to expand our winter production to over 30 acres and couldn't find anyone prepared to take on this job. So I turned to Al Bevis, a large rice farmer in Belize. Al had grown alfalfa seed for FFR when he farmed in California and was one of FFR's first Directors.

IN ADDITION to the FFR work, when the American Soybean Association indicated that several public and private breeders felt there was a need to develop a winter nursery available to all soybean breeders, Al Bevis offered to start a service company in Belize to aid plant breeders.

Belize is the English-speaking country formerly known as British Honduras, located on the Caribbean, due south of New Orleans. He named the corporation, Continuous Crop Improvement Company (CCIC).

WHERE SHOULD a winter nursery be located? Al had three alternatives: (1) Near his rice farm, (2) on the inland rolling hills, or (3) on the sandy, coastal plains.

The rice farm is located on heavy clay, flood-plain soils about 80 miles above the mouth of the Belize River. These soils are quite fertile. But Belize's 90 inches of annual rainfall often makes it difficult to plant and harvest soybeans in a timely fashion.

The inland, rolling hills are fertile, but are relatively inaccessible, and hotel accommodations are limited. Near the international airport was ample acreage of sandy, coastal plains that were unfarmed, for they were regarded as unproductive.

All they needed was 86 pounds N, 94 pounds P_2O_5 and 49 pounds of K_2O with micronutrients. Eight hundred pounds of lime was applied per acre. This is where CCIC has successfully developed land to grow soybeans, cotton, sunflowers and sorghum for United States plant breeders, who get to their plots by taxi from the international airport.

Sorghum yields of 5,000 pounds per acre can be obtained when adequate amounts of N, P and K are applied. **The End**

Snap Bean Response To Fertilization

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WITH ITS FAVORABLE climate for snap beans, the Cumberland Plateau of Tennessee has become an important center for commercial snap bean production. During the past 40 years since the inception of the industry, many changes have occurred—namely in cultivars, harvesting, cultural practices, and marketing arrangements.

Most of the agricultural soils of the Cumberland Plateau are residual, derived from sandstone and some shale.

They are strongly acid, low in phosphorus, organic matter, and certain micronutrients. The fertility of these soils has been improved greatly in the past few years by adding lime and commercial fertilizers. But many problems still exist.

This article reports results of tests that have been conducted periodically on snap beans at the University of Tennessee Plateau Experiment Station. These particular tests were initiated to determine levels of nitrogen, phosphorus, and potassium optimum for snap beans grown on Plateau soils.

EIGHT FERTILIZATION TESTS on Hartsells sandy loam soils were conducted on snap beans between 1946 and 1975. Soil reaction, levels of available phosphorus and potassium of test plots, and the snap bean cultivars grown are shown in **Table 1.** Tests in 1965-66 were conducted successively on identical plots.

In all tests, the experimental design used was an incomplete factorial with a randomized, complete block design of treatments. With this design, a level of nitrogen, phosphorus, and potassium was chosen as a control and the levels of the individual nutrients were varied one at a time above and below the control levels.

Plot size, row width, in-row spacing, number of treatments, and replications have varied somewhat over the years, but have been in the range of two-row, 25-30 foot plots, 30-38 inch row spacings, 8-10 plants per foot, 11-14 treatments, and 3-4 replications.

Fertilizers have been applied as a band at planting 2 inches deep and to the side of the row. Standard cultural and pesticide practices have been followed.

Table 1. Reaction and available phosphorus and potassium of soils of research plots and cultivars used in snap bean fertilization studies, 1946-75.

Year	pH	Available[1]		Cultivars
		Phosphorus	Potassium	
1946-47	5.1	low	low	Tendergreen
1958-59	5.3	med	low	Tendergreen
1965-66	6.3	med	low	Wadex
1975	6.1	high	med	Eagle, Slenderwhite

[1]UT Soil Testing Laboratory.

Since 1965, all plots have been mechanically harvested in a once-over operation. Before 1965, plots were hand-harvested two to four times.

Harvesting was begun when about 30% of the pods were seive size #5. The 1975 tests involved two successive plantings of two cultivars.

Records taken included yields, plant characteristics, and selected pod quality attributes. Only yields are reported in this paper.

FERTILIZER TREATMENTS and corresponding yields for each 2-year test period are given in **Tables 3-6**. To simplify and avoid dealing with decimals, the levels of phosphorus and potassium are expressed as their respective oxides. Yields are expressed in bushels per acre. A 200-bushel yield corresponds to 3 tons.

Yields were significantly influenced by fertilizer treatments in 7 of the 8 test years, but more highly in some years than in others.

In practically all tests, yields from plots that received no fertilization or 0 levels of any one of the three nutrients compared were significantly lower than those from other plots.

In certain instances, yields from plots receiving high levels of all three nutrients were slightly less than those from plots receiving medium to low levels. Plant stands were reduced slightly in certain plots receiving high levels of potassium, notably in 1966 when the rainfall was less than optimum as indicated in **Table 2.**

Throughout the test period, the plots receiving the medium to high levels of the nutrients yielded highest. In most cases, differences in yields among the nutrient levels greater than 0 were not significantly different from each other **(Tables 3-6).**

Where levels of phosphorus and potassium were held constant, the yield

Table 2. Weekly rainfall, total rainfall, planting dates, and harvest dates for snap beans in fertilization studies, 1946-75.

Week of growth period	Rainfall							
	1946	1947	1958	1959	1965	1966	1975[1]	1975[2]
	Inches							
1	0.0	0.16	0.62	2.35	0.97	0.20	1.12	0.0
2	0.95	1.70	0.55	0.06	3.83	1.21	1.98	0.76
3	0.58	1.73	0.25	1.75	1.68	1.14	0.0	0.98
4	1.97	0.86	1.02	1.19	1.13	0.02	1.10	0.91
5	1.09	1.54	0.41	1.82	0.68	2.19	0.66	0.72
6	1.02	0.73	1.38	1.18	0.22	0.71	1.01	0.25
7	0.0	0.32	0.93	0.85	1.94	0.33	0.60	1.80
8	1.13	0.86	3.37	1.21	2.10	0.79	0.25	0.26
9	2.83	0.75	0.72		0.08			
10		0.16	1.04					
TOTAL	9.57	8.81	10.29	10.41	12.63	6.59	6.72	5.68
Planting Date	7/11	6/12	5/23	7/23	5/12	6/1	6/4	6/19
Harvest Date	9/12*	8/18	8/5*	9/23*	7/9	7/26	7/29	8/12

*Last date of two-four successive hand harvests.
[1]Crop 1, planted 6/4, harvested 7/9.
[2]Crop 2, planted 6/19, harvested 8/12.

Table 3. Yearly and average yield of snap beans fertilized with various levels of nitrogen, phosphorus, and potassium at Plateau Experiment Station, Crossville, 1946-47.

Nutrient levels			Yield		
N	P_2O_5	K_2O	1946	1947	Average
	lb/A			bu/A	
0	0	0	169	198	183
0	72	72	210	249	229
24	72	72	275	268	271
48	72	72	304	256	280
72	0	72	167	138	152
72	24	72	283	169	225
72	48	72	254	205	229
72	72	0	300	263	281
72	72	24	302	275	288
72	72	48	326	273	299
72	72	72	283	230	256
Overall Average			260	229	
LSD @ 0.05			70	40	

Table 4. Yearly and average yield of snap beans fertilized with various levels of nitrogen, phosphorus, and potassium at Plateau Experiment Station, Crossville, 1958-1959.

Nutrient levels			Yield		
N	P_2O_5	K_2O	1958	1959	Average
	lb/A			bu/A	
0	80	40	340	217	278
40	80	40	436	247	344
80	80	40	437	230	333
40	80	80	457	260	358
40	160	40	433	250	341
40	160	80	453	263	356
80	80	80	437	230	333
80	160	40	423	233	328
80	160	80	437	243	340
40	80	0	387	217	301
40	0	80	460	217	338
Overall Average			427	236	
LSD @ 0.05			61	NS	

response to nitrogen occurred in 1946-47 and 1958-59 **(Tables 3, 4),** but not in 1965-66 or 1975. **(Tables 5, 6).** And in most cases, the response was between 0 and the lowest level tested.

In a nitrogen fertilization study on two Blue Lake bush bean cultivars, Coffey and Mullins reported an increase in plant size and subsequent lodging with increasing levels of nitrogen fertilization.

Table 5. Yearly and average yield on snap beans fertilized with various levels of nitrogen, phosphorus, and potassium at Plateau Experiment Station, Crossville, 1965-66.

Nutrient levels			Yield		
N	P_2O_5	K_2O	1965	1966	Average
	lb/A			bu/A	
0	0	0	248	77	162
0	75	40	219	111	164
20	75	40	237	115	176
40	75	40	232	110	170
60	75	40	233	108	170
80	75	40	220	128	173
40	0	40	244	82	162
40	50	40	255	127	190
40	100	40	196	113	154
40	125	40	201	105	153
40	75	0	245	90	167
40	75	20	233	105	168
40	75	60	193	105	148
40	75	80	221	101	160
Overall Average			226	105	
LSD @ 0.05			40	28	

Table 6. Individual crop and average yield of snap beans fertilized with various levels of nitrogen, phosphorus, and potassium at Pleateau Experiment Station, Crossville, 1975.

Nutrient levels			Yield		
N	P_2O_5	K_2O	1975[1]	1975[2]	Average
	lb/A			bu/A	
0	0	0	268	148	208
0	75	40	275	225	249
20	75	40	284	225	254
40	75	40	311	221	266
60	75	40	325	221	273
40	0	40	280	147	213
40	50	40	284	209	246
40	100	40	282	199	240
40	75	0	286	188	236
40	75	20	310	197	253
40	75	60	299	198	248
Overall Average			291	198	
LSD @ 0.05			25	43	

[1]Crop 1, planted 6/4, harvested 7/9.
[2]Crop 2, planted 6/19, harvested 8/12.

In some cases, they reported yield reductions from levels of 60 pounds per acre nitrogen which they attributed to decreased mechanical harvesting efficiency due to the greater degree of plant lodging associated with the higher nitrogen levels.

AN INCREASED YIELD response from phosphorus when nitrogen and potassium were held constant occurred in 1946-47, 1965-66, and 1975. (Tables 3, 4, 6). In these instances, the 48-50 pound per acre levels resulted in the greatest yields.

Higher levels resulted in a slight depression in yields. Possibly this response is related to zinc availability as the influence of phosphorus additions on zinc solubility and availability is not clear.

In some cases, phosphorus additions have contributed to zinc deficiency. Lime has been shown to influence the uptake of zinc by crop plants grown on Hartsells soils which are inherently low in zinc content, according to work by Coffey and Mullins and L. F. Seatz et al.

In these cases where levels of phosphorus greater than 50 pounds per acre were banded in the root zone, it may have created a zinc situation that was less than optimum.

With the exception of 1975, yield response from all potassium levels greater than 0, with nitrogen and phosphorus held constant, has been negligible **(Tables 3-6)**. In certain tests, yields from plots receiving 0 levels also did not differ from those receiving other levels.

The overall responses in yields between the test years are shown in **Tables 3-6.** Generally, no large response in yields among fertilizer treatments for a single year resulted, but the differences in overall average yields between test years were evident.

In all tests, there was a highly significant difference between years, or in the case of 1975, between crops. The test period 1965-66 shows greatest variation between years, but slight differences among treatments for the individual years **(Table 5)**.

THE DIFFERENCE in total rainfall and weekly distribution between the 2 test years can explain much of this variation. Notice from **Table 2** that the 1966 crop received only about one-half the amount of rainfall as the 1965 crop did.

And during the critical period of pod development, the 1966 crop received only 0.71, 0.33, and 0.79 inches per week. This resulted in less total foliage growth, and the associated higher temperatures that year hastened pod maturity.

Somewhat the opposite occurred in 1959, when rather large amounts of rain — 2.35 inches — occurred during the cooler germination period of the crop, causing a higher incidence of root rot which tended to reduce plant stand and subsequent yields.

The variability between two crops in 1975 was less than between any other 2 test years. The variability that occurred in 1975 was probably due more to temperature and light conditions than rainfall, as both crops received about equal rainfall and were grown in adjacent plots on identical soils.

ESTIMATES between yields and levels of nutrients for the 8 years of the study were made and are graphically illustrated in Figures 1-3. Both linear and quadratic comparisons were made for all nutrients and levels.

The relationship of yield to nutrient levels is best described linearly. But in the case of potassium, the quadratic comparison was approaching significance **(Figure 3)**.

As explained earlier, control levels were chosen and the nutrients were varied one at a time above and below the control levels.

With the exception of years 1946-47, the control levels were 40, 80, and 40 pounds per acre of nitrogen, P_2O_5, and K_2O, respectively. Control levels for 1946-47 were 48-72, and 48 pounds per acre.

The yield response from five levels of nitrogen is illustrated in **Figure 1.** Each 20-pound increment of nitrogen resulted in an **8.5 bushel per acre increase in yield.**

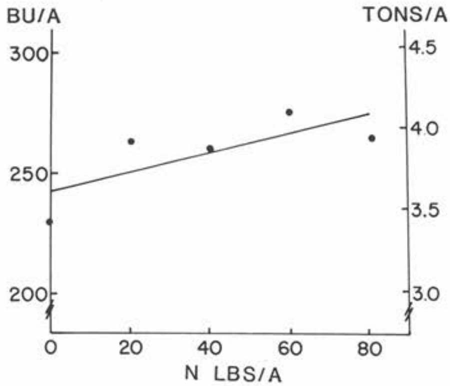

FIGURE 1

The yield response from five levels of phosphorus is illustrated in **Figure 2.** Each 20-pound increment of P_2O_5 resulted in a **5.8 bushel per acre increase in yield.**

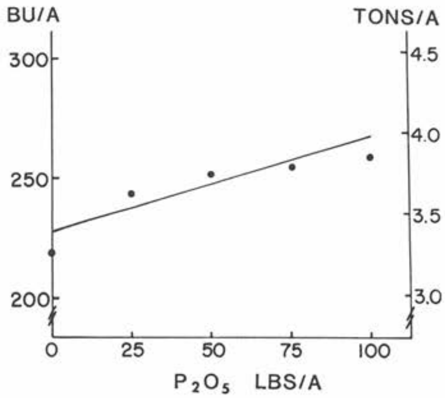

FIGURE 2

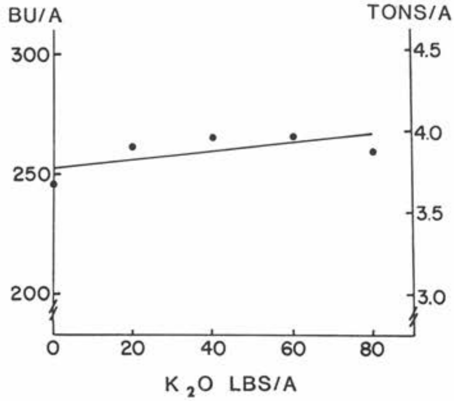

FIGURE 3

The same information for potassium is illustrated in **Figure 3.** Each 20-pound increment of K_2O resulted in a **3.25 bushel per acre increase in yield.**

As can be seen from these data, the yield response over the combined 8-year period was greatest from nitrogen, followed by phosphorus and then from potassium.

Regression analyses of data from the individual tests, however, showed that this order and magnitude of yield response to nutrients and levels varied widely from year to year—further illustrating the influence of **environmental conditions** on snap bean yields. **The End**

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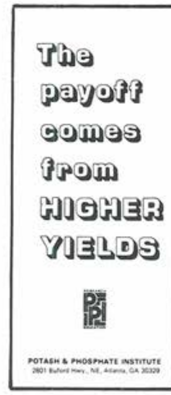

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