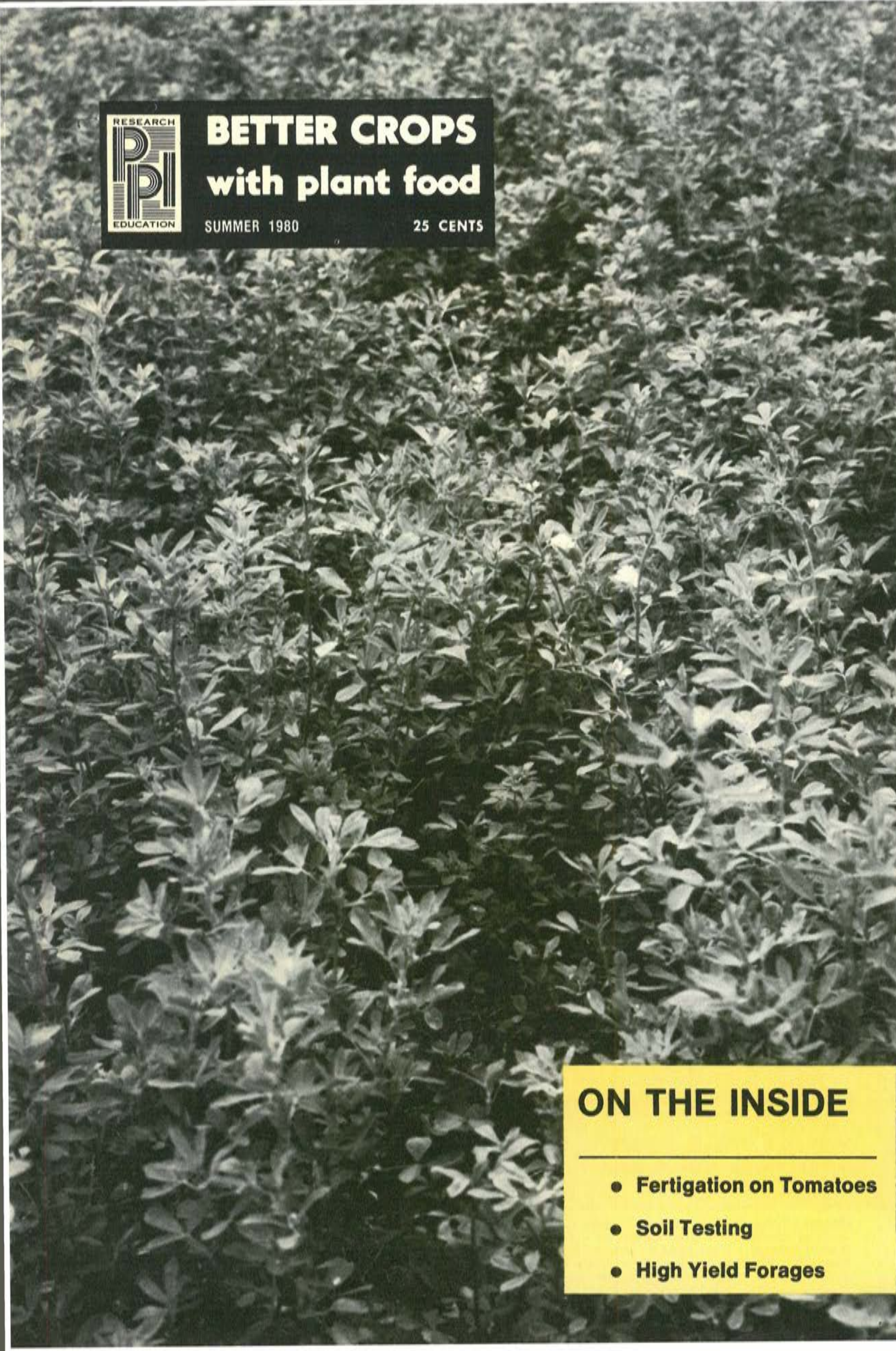
RESEARCH PPI EDUCATION

BETTER CROPS with plant food

SUMMER 1980 25 CENTS



ON THE INSIDE

BETTER CROPS with plant food

Vol. LXIV **SUMMER 1980**

BETTER CROPS (USPS 396850) is published quarterly by the Potash & Phosphate Institute. Subscription price is $1.00 per year or 25c per copy. Controlled Circulation Postage Paid at Atlanta, GA. **Postmaster:** Send address changes to Potash & Phosphate Institute, 2801 Buford Hwy., N.E., Suite 401, Atlanta, GA 30329.

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FERTIGATION: A Tomato Study in New Jersey

JIM PATERSON
Rutgers Research & Development Center

IRRIGATION is a common practice for the New Jersey vegetable grower. Irrigation limits moisture fluctuation and is a must for the high yield of quality product which is necessary for a profitable vegetable enterprise.

Utilizing a drip-trickle type irrigation system to apply part of the crop's fertility needs has not been widely practiced and needs to be studied.

We ran a fertigation trial in 1979 with Pik Red (Red Pak) tomatoes grown on a Sassafras sandy loam soil. The beginning soil test levels were:

pH	7.0
P	very high
K	medium
Mg	very high

Preplant fertilization of 30-30-30 lb/a N, P_2O_5, and K_2O was applied on May 1st to one half of the plots. Prior to transplanting the tomatoes on May 4th, a 4 foot wide, 1½ mil black plastic mulch was laid as a 4 mil twin-wall drip tube was being inserted into the soil 2 inches deep and 6 inches to the side of the plant row.

The tomatoes were fertigated six times (6/15, 6/20, 6/27, 7/3, 7/11, and 7/17) with a soluble 20-20-20 fertilizer which had micronutrients included. The fertilizer was applied so that either 5, 10 or 20 pounds of the major plant nutrients were applied during each of the six fertigations.

Yield, and profit potential were greatly increased by fertigation. Note the tremendous impact that a combination of preplant fertilization and fertigation had on production of No. 1 tomatoes.

The high percentage and the uniform quality of the No. 1 fresh market tomatoes **has never been better at our Research Center in South Jersey.**

We plan to further research the use of fertigation using other fertilizer combinations on other vegetable crops.

Pounds of N, P_2O_5 & K_2O per application	No Preplant Fertilization		With Preplant Fertilization	
lb/a	Yield	Gross Return*	Yield	Gross Return*
	t/a	$/a	t/a	$/a
5	10.1	4,040	16.4	6,560
10	11.6	4,640	22.0	8,800
20	20.5	8,200	28.1	11,240

*based on a price of $20 per cwt.

High yielding field trials like this are necessary to calibrate soil tests. They require highly skilled workers. To test response to a plant nutrient, all other limiting factors should be eliminated. A field test for phosphorus or potassium response, when nitrogen may become limiting, is wholly misleading.

Soil Tests for High Yield Agriculture

J. F. REED & W. L. NELSON

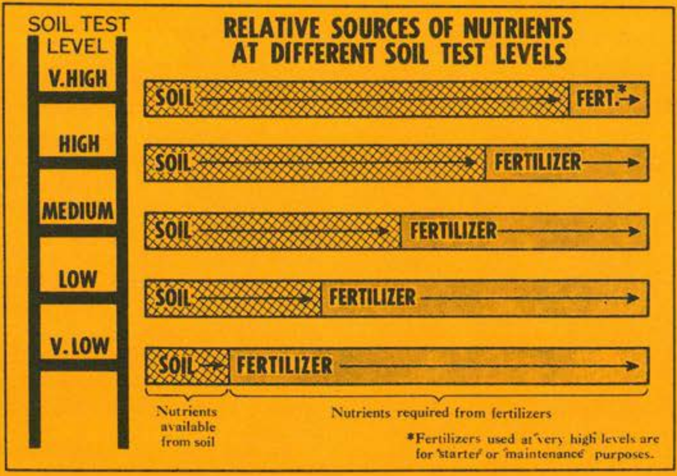
PROPERLY CALIBRATED chemical soil tests are valuable for predicting fertility needs and monitoring soil nutrient status. In these tests we expect a chemical extractant, in contact with the soil for a few minues, to extract an amount of a nutrient that is indicative of the amount available to plants during their growing period.

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

To use soil tests most effectively in modern high yield agriculture, many points must be recognized:

1. Keep research up to date in high yield age

Research is needed to determine the plant nutrient level necessary for **continuous** top economic yields. Field and greenhouse experiments must be constantly conducted to calibrate or standardize soil tests. Many field studies today are already out of date because (1) out-moded practices are used and (2) limiting factors are not eliminated.



Here is a simple interpretation of soil tests. As the soil tests higher in a plant nutrient, the amount needed from fertilizers becomes less. Even at high levels some of the nutrients come from fertilizers. This maintains fertility and provides insurance.

For example, soil tests calibrated for 135 bushels of corn per acre, when farmers are interested in 185 bushels, are behind times.

Dr. J. W. Johnson at Ohio State University states, "Much of our present correlation data relating crop yields to soil nutrient status goes back to Dr. Roger Bray. His data were collected from 1938 to 1941. Top corn yields ranged from 40 to 103 bu/A. If we used his data to predict nutrients required for 200 bu/A corn, we could be grossly wrong."

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

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

2. Time and method of sampling can be important

While there has been some improvement in sampling, still one of the greatest problems in soil testing is failure to get a sample that is truly representative of the conditions that we are trying to measure.

Too often ignored are studies of sampling techniques that point out the many possible errors that can result from: Failure to include enough borings per composite sample; failure to properly divide the fields; failure to simply cover the whole area properly, and, in fact, from just plain carelessness or laziness.

To this should be added the failure to take into account the time of sampling, and the location of the boring with regard to time and method of fertilizer placement. Should samples be taken under the growing crop? . . . in the fall or in the spring?

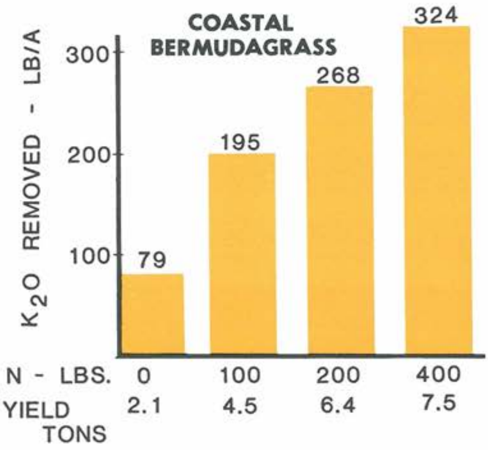
Then there's the sample preparation in the average receiving room . . . sometimes pretty careless . . . hardly suitable for the exotic treatment the sample will soon experience in the modern laboratory.

To further complicate the picture, there is the question of subsoil sampling . . . yes or no? And drying the sample . . . yes or no?

It's amazing how much confidence is frequently placed in the analysis of a sample about which so little may be known.

3. Laboratory methods promote accuracy

Improved laboratory equipment, techniques, and methods have been a great help to soil testing. The use of spectrophotometers, spectrographs, better pH meters, and newer methods have in-



Omitting addition of an element because the soil test shows it is "high" leads to soil depletion. The removal of potash goes up as grass yields are increased by adding more nitrogen.

creased the speed and precision of laboratory determinations.

Laboratories run check samples periodically to be sure the apparatus and solutions are OK.

In the past, soil test improvements usually referred to the development of new and better lab tests. There was no point in developing other phases of testing until the accuracy of laboratory tests was assured.

But with the assurance of precise tests for the major nutrients, the main problem now is to be sure the method used is suitable for the soil being tested and produces the information desired.

4. Interpreting soil tests: The pay-off

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

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

"The chances of getting a profitable response to fertilization are much greater on a soil that tests low in a given nutrient than on one that tests high.

"This does not rule out the possibility of a profitable response from fertilizer application at a high level of fertility, if yield factors other than fertility are optimum. Likewise, a profitable response on soils of low fertility is not assured when other factors such as climate or management are poor.

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

Purdue indicates that with a low soil test, there is a 70-95% chance of getting a yield response. With a high test there is a 10-40% chance.

With top level management practices, yields increase and the probability of a response at any given soil test likewise increases.

Things are not always as clear as we think. A Wisconsin demonstration involved three sites, based on soil test levels. The highest test site gave the best yield. However, **it also produced the greatest response when fertilizer was added.**

There are many unanswered questions in soil testing as related to high yield levels. Many think we have arrived, when we have only begun to learn what the possibilities are.

Dr. Welch, University of Illinois, writes: "It is generally recognized that as we strive for higher yields, soils should test in the high level for P and K. Check the general level of P and K.

"If the soil is medium or less, buildup plus maintenance should be applied to bring the soil to high. Then check the P and K soil test levels every two or three years to make sure the test levels are building to high and once there, are being maintained.

"Since buildup is a one-time process, I suggest that the difference in cost associated with moderate differences in suggested buildup levels becomes almost inconsequential when considered over the appropriate long-term basis . . . It is not good economic sense to add large amounts of unneeded fertilizer. But, it is even more unwise to suffer economic loss because too little fertilizer is applied."

5. Basic question: What does the farmer want?

Most farmers who have soil samples tested are in the upper 25 percent. They expect recommendations for better yields.

Some interpreters use soil tests to see how much fertilizer can profitably be applied. Others use soil tests to see how little fertilizer the farmer can get by with.

Ten years from now the "average" farmer of today will no longer be on the farm unless he is simply waiting for retirement.

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

6. Making recommendations—now done by many

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

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

Also, many farmer-businessmen want more than a fertilizer recommendation. They want a complete set of plans to meet a high yield goal. This calls for the inclusion of all relating factors—proper variety, cultural practices, time of planting, proper use of pesticides, etc.

Under these circumstances consulting agencies may be used by farmers to sample the soil and also the plant and to monitor the crop throughout the season. This adds a new dimension to soil tests.

In most cases, industry and commercial laboratories are just as well equipped as state labs to run soil tests with precision. The numerical results that one lab reports may differ from that of another lab, but this does not mean that one lab is correct and the other wrong.

The numerical figure is relative, and its meaning in terms of high, low, or medium depends on the calibration system and also the philosophy of making recommendations.

Two scientists could recommend different rates of nutrients from the same soil test, depending on many factors, such as yield goals, building or depleting plans, and especially the type of farmer for whom the recommendations are being made.

For this reason, the use of computers for making recommendations must be carefully evaluated, and the computer read-out should be subject to modification by those who know the past history, the management practices of the farmer, and the many local facts that are part of yield determination.

It is hard to visualize a medical doctor making a diagnosis on the basis of a blood sample mailed in by a patient, analyzed, and run through a computer. The doctor would want to see the patient, ask questions, get a history, and use the blood analysis primarily as a diagnostic aid.

7. Recommendations when levels are high

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

Most laboratories assign the value "high" not to such very high conditions but to a level at which the odds point to little or no response to applications of that nutrient that year.

At the same time, failure to apply any of this nutrient will surely result in a depletion of that plant food. Also, under some conditions crops will respond profitably to a nutrient even with a high test, as mentioned earlier.

We sometimes tend to ascribe a degree of accuracy to the soil test values that was never intended. The most "accurate" data are merely relative and usually must be interpreted back into general terms.

A certain number of pounds of available P or K may be "high", "medium", or "low", depending on the crop requirements or on other soil conditions.

Often farmers fail to place a price tag on residual fertility. While immediate return on the fertilizer investment is important, the better farmers are interested in big returns over the years.

In many cases, just the residual value of the fertilizer the year after application pays the original investment plus interest.

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

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

8. Secondary and micronutrients

As yields go up and soil depletion increases, more emphasis must be focused on plant needs for secondary and micronutrients. This opens a relatively new soil testing field.

It calls for a vigorous research program to evaluate the possibilities of using routine soil tests to determine needs for these elements.

Under certain conditions, a soil test for boron, zinc, or manganese may be helpful in making recommendations. Many agronomists feel that plant analysis is more useful than soil analysis for certain secondary nutrients such as sulphur and for some micronutrients.

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

9. Lime recommendations sometimes off —Why?

Probably the most widely used tests are those that serve as a basis for lime recommendations. But in some instances lime amounts recommended have been inaccurate.

There are many reasons for this, including quality and fineness of lime, how recently it was applied, mixing, and depth of plowing, time of year of sampling, and use of high amounts of N fertilizers.

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

10. What do soil tests mean?

In the 1940's, 50's, and 60's soil fertility levels and yield levels were low and fertility level was an important controlling factor in crop yields.

Now, fertility and yields are higher and as the better farmers strive for higher yields and quality, other factors become increasingly important along with fertility. The goal is to build soil **productivity**, as well as fertility.

Long term fertility trials are essential if soil test calibrations are to be meaningful. Most farmers operate on a long time basis.

Some of the discrepancy between experimental results and farmer yields may be due to the farmer's greater persistence. The cumulative effect in the better farmer's fields may put him beyond any responses or interaction encountered in short term trials.

Soil tests are very useful diagnostic tools. And that is just what they are—tools. To consider a soil test as an infallible miracle worker is to misuse it.

The moral: Recognize the value of a soil test—but also recognize the need for additional information and understanding if the test is to be most effective in recommending fertilizer for maintaining high productivity, yield, and profit.

In summary

1. A soil test measures the relative soil fertility level.

2. High yield research must determine the fertility levels of the entire soil profile at which most profitable yields are consistently produced.

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

4. For soil testing to be even more helpful and more reliable in high yield agriculture, there must be more long-term correlation research at high yield levels. Also, more attention must be devoted to proper sampling time and techniques.

5. Soil tests are important in planning a long time fertility program. Sampling periodically and maintaining records of nutrient levels, yields and all management practices is a must. The End

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Animals As Well As Forage Respond to Applied Phosphate

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CSIRO, Perth, Western Australia

FEED GROWN with more phosphorus may make animals eat more and digest it better, with resulting increased production.

Recent work has shown superphosphate does more than increase forage yield, encourage legumes to flourish, and supply minerals for grazing stock.

Increased palatability was shown clearly in a field experiment in which sections of a newly sown clover pasture were fertilized with 9 levels of P applied as double superphosphate.

To prevent other elements confusing the responses, the whole area was fertilized with gypsum to supply Ca and S, with muriate of potash, and with salts of Cu, Zn and Mo. During the growing season the forage was grazed at 7.5 sheep per hectare, all sheep having free access to all plots.

At the end of the growing season the feed available on all phosphate treatments was measured, and common grazing was continued. Just before the next season, the forage residues still available were again determined.

The decrease in dry feed on offer was a measure of the amounts eaten, plus any trampling or weathering effects. Since only about 70 mm of precipitation had occurred over this period, weathering was slight.

Although the sheep had free access to all P treatments, they showed a marked preference for those given high P levels—so much so that at the end of the period there was more than twice as much dry clover left on the lowest P treatment as there was on the highest. The relationship between P applied and forage removed under grazing is shown in **Figure 1.**

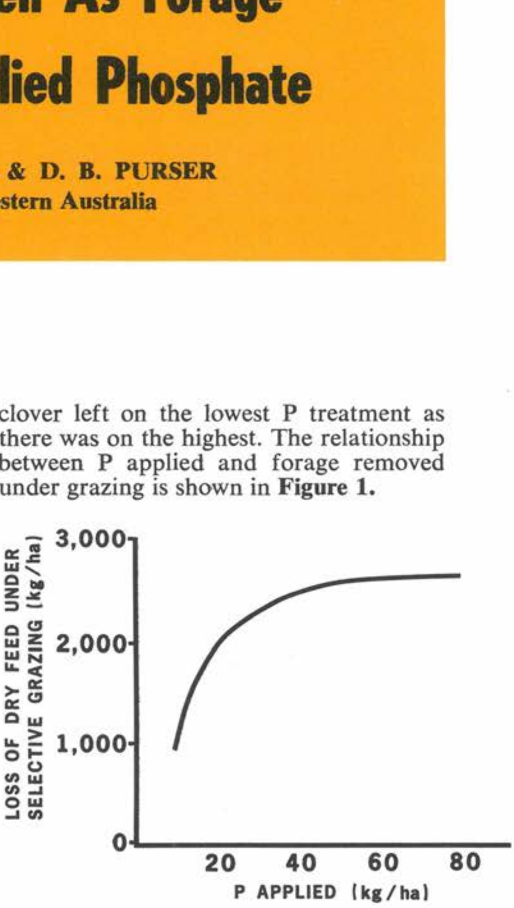


Figure 1. The effect of phosphate broadcast at the beginning of the growing season, on the palatability to grazing sheep of the dry feed residues on offer until the commencement of the next season. Plots were grazed in common by one group of sheep with free access to all plots.

IN THE SECOND EXPERIMENT, three rates of double superphosphate equivalent to 6.2, 13.4 and 30.8 kg of P per hectare were applied.

On a different soil in the **third experiment,** we applied mixtures of double and single superphosphate and gypsum so that three paddocks received similar levels of calcium and sulphur, and carried the same amounts of available soil phosphorus as in

	Superphosphate level applied to the pasture			
	Low	Medium	High	Low, plus Phosphorus supplement
Phosphorus in the feed (%)	0.07	0.11	0.23	0.30
Amount sheep ate (g/day)	1042	1120	1420	1293
Proportion they digested (%)	44	40	49	39
Growth rate of sheep (g/day)	-18	16	124	33

Table 1. Giving a phosphorus supplement to sheep on low-phosphorus feed helped them eat more, but they didn't do as well as the sheep on the high-phosphorus feed.

the second experiment. The rates were 28, 95 and 296 kg of applied P per ha.

The forage, a clover-ryegrass mixture didn't yield any more with the heaviest applications than it did with the medium ones. But we wanted to find out whether the sheep would benefit from the extra phosphorus. When the pasture had matured, we ground and pelleted it and fed it to young crossbred wethers in pens.

Results from both experiments were similar. And those from experiment 3 are given below. Chemical analysis showed that the phosphorus level in the feed increased from only 0.07% in the lightly supered paddock to 0.23% in the one getting most super. See **Table 1.**

As the phosphorus content increased, so did the appetites of the sheep. With the medium- and low-phosphorus rations, the sheep followed the normal rule. That is, the greater the amount of feed they ate, the smaller became the proportion of it they could digest. But the sheep on the high-phosphorus feed, even though they ate far more than the others, digested a higher proportion of it.

The low-phosphorus ration wasn't good enough to sustain the sheep. They excreted more phosphorus each day than they ate, and lost weight. Even those on the medium-phosphate diet barely gained weight, but those on the 'luxury' diet grew well.

To see just how much of this response was due to the simple addition of phosphorus to the diet, we supplemented half of the sheep on the low ration by adding sodium and potassium phosphate to the pellets.

We found that one-third of the improvement had been due to more phosphorus. With extra phosphorus in their pellets, the sheep on the low diet ate more and could put on weight. **But the digestibility of the feed didn't change, so supplementing with phosphorus was far less effective than supplying it via the fertilizer.**

It seems that some other factor was involved. We think that the **higher fertilizer rate may have changed the cellulose and hemi-cellulose in the plants and enabled the sheep to digest a higher proportion.**

Although three times more phosphorus had been applied than the pasture needed for maximum production, the sheep still increased their growth in direct proportion to its phosphorus content. See **Figure 2.**

THESE THREE EXPERIMENTS were all carried out on dry pasture residues normally lower in P content than green forage. **However, we have had similar results with animals grazing green feed.** In one such experiment we applied 5 levels of P to an old, well fertilized clover-grass pasture.

The plots were then differentially grazed until there was an equal amount of feed on offer on all treatments. The experimental flocks of sheep of similar weight were then put on the different P treatments. Body weight gains were measured and their relationships to levels of applied P are shown in **Figure 3.** The shape of the response curve is similar to that in **Figure 1.**

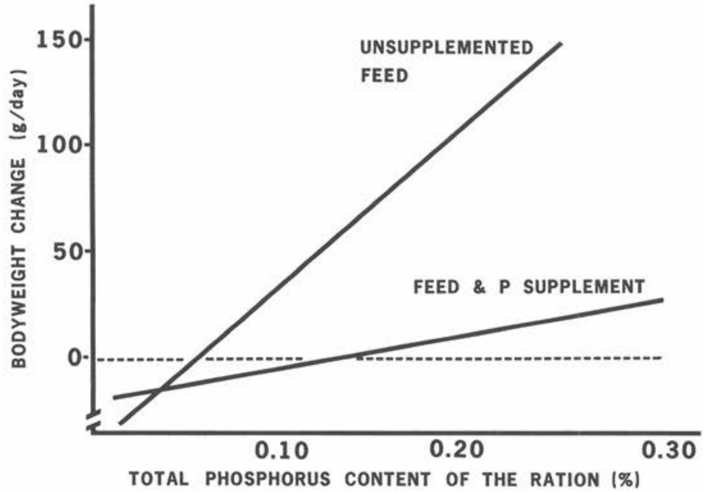


Figure 2. The relationship between phosphorus concentration in dry summer feed and body weight change over a period of unrestricted intake.

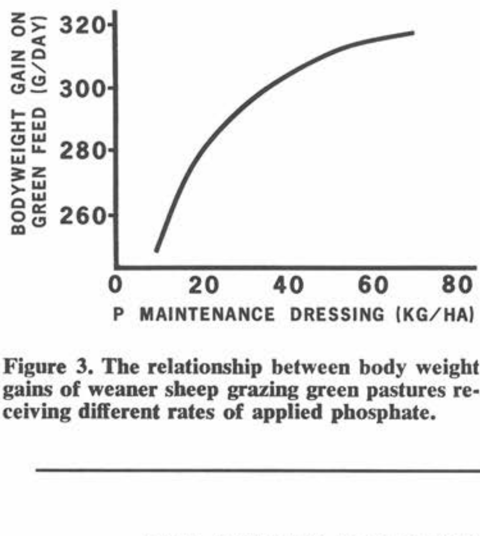


Figure 3. The relationship between body weight gains of weaner sheep grazing green pastures receiving different rates of applied phosphate.

These four experiments, and a number of other related studies which we have still in progress, indicate four things. Higher levels of applied phosphate increase the P content of pastures. This is associated with increased palatability, increased feed intake and often increased digestibility.

Inorganic phosphate supplements in the feed are only partially successful in conferring these benefits. **So it seems that increasing the P supply to growing pasture increases the feed quality in more ways than just giving a higher P content. The End.**

N-K Balance for Coastal Bermudagrass

C. E. EVANS
Auburn University

WHEN COASTAL BERMUDAGRASS is fertilized with high nitrogen rates, the potassium needs must be met or yields will suffer.

The K need for sustained yields under different N systems was determined in a 5-year study at Brewton, Alabama. Rates of N were 200, 300, 400, and 600 lb. per acre with superimposed K rates. All plots received 115 lb. P_2O_5 per acre.

Figure 1 shows the 5-year average forage yields. The 400 lb. N rate gave maximum forage response with no further increase from 600 lb. N. At each N rate there was a yield increase from K fertilizer.

Yields were not widely different for K rates ranging from 50 to 300 lb. of K_2O when only 200 lb. of N was applied. But the highest yield was from 300 lb. of K_2O. With 300 lb. N, 100 lb. K_2O was not enough for top yields, but 200 lb. of K_2O gave top yields.

When the most profitable N rate of 400 lb. was used the K requirement was 300 lb. K_2O per acre.

FORAGE YIELDS for individual years for the 400 lb. N treatment with 200 and 300 lb. K_2O per acre is shown in **Figure 2.** These fluctuations in yields reflect the effects of weather conditions during the 5-year period.

In all years, regardless of rainfall, 300 lb. of K_2O gave higher yields. Even in

Table 1—Yield of Coastal Bermudagrass in N-K Experiment
Brewton Experiment Field

Treatment		1972	1973	1974	1975	1976	Avg
N	K_2O	Lb/acre oven dry forage					
0	80	1438	2842	2955	2941	1870	2409
100	40	6700	8598	8816	9525	6711	8070
100	80	6331	9239	8659	9774	6679	8136
200	0	11390	9692	7225	6119	4616	7808
	50	11966	13213	13504	12883	12110	12735
	100	10483	12635	13230	12188	11592	12026
	200	12764	14303	13330	13198	12076	13132
	300	13552	15153	14221	13869	12768	13912
300	100	16105	16174	14301	12961	12872	14482
	200	15552	18002	17008	15357	15204	16224
	300	14041	17626	16974	14575	16187	16080
	400	15532	17528	17116	15304	16381	16372
400	200	17189	19191	17711	14944	16762	17159
	300	20002	21267	19679	15347	17535	18766
	400	19151	21855	19901	15533	17329	18754
	500	20620	20640	19461	15635	17745	18820
600	200	17390	16728	14508	11788	14356	14954
	300	18069	20322	19017	13861	17889	17831
	400	20899	21415	19296	15583	17982	19035
	500	20466	22012	19407	16314	18797	19399

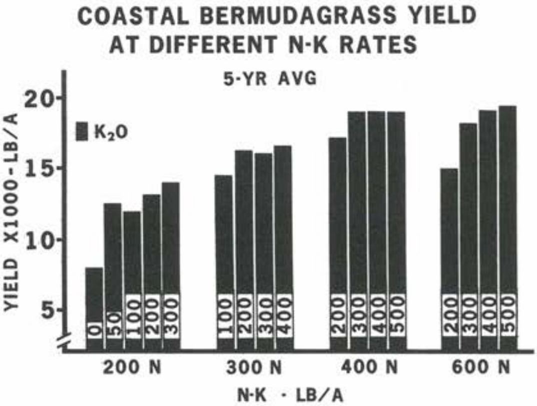


FIGURE 1

1975 when yields were lowest the 300 lb. rate of K_2O gave higher yields than 200 lb. of K_2O.

Figure 3 shows the influence of K in 1975 was even more striking when the 600 lb. N rate was used. In this case, 200 lb. K_2O and 600 lb. of N produced less than 6 tons forage per acre.

Increasing the rate of K_2O to 400 lb. raised forage yields to nearly 8 tons per acre.

The effects of K rates on soil test K is given in the table. Inadequate K resulted in depletion of soil K. The rates which gave highest yields also maintained a satisfactory soil test K level.

These results indicate proper fertilization is an important practice in maintaining yields regardless of weather conditions. Also, these data establish the necessity for basing K_2O rates on the N management system. **The End**

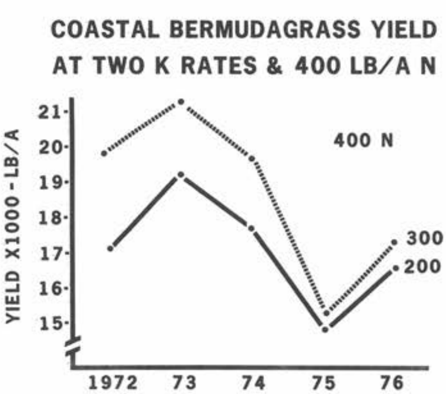


FIGURE 2

Table 2—Rainfall Data at Brewton Experiment Field

Month	1972	1973	1974	1975	1976
April	2.08	5.66	3.72	11.09	2.87
May	9.66	5.05	5.47	6.84	9.76
June	4.44	9.24	2.49	5.61	3.25
July	2.92	3.74	7.17	18.16	5.76
August	1.71	2.77	5.48	4.43	3.12
5 Month Total	20.81	26.46	24.33	46.13	24.76

Table 3—Soil tests at beginning and at termination of experiment—Brewton, Alabama

Treatment		Soil Test K	
N	K_2O	1972	1977
		LB/A	
200	0	58	28
200	200	64	103
300	100	58	35
300	300	80	120
400	200	69	55
400	400	85	135
600	200	42	49
600	400	73	100

All plots were "high" in P and received 115 lb P_2O_5 per acre as maintenance.

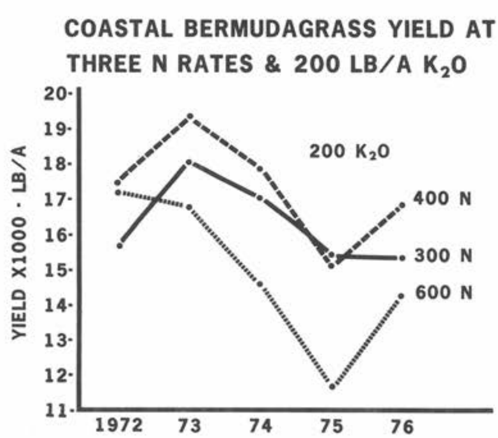


FIGURE 3

Phosphorus Boosts Productivity of Grazing Animals in Western Canada

J. E. KNIPFEL
Research Branch, Agriculture Canada
Swift Current, Saskatchewan

ACROSS WESTERN CANADA about 50 million acres of land are in permanent pasture and range, with the great majority of this land area devoted to beef cattle production. Also, in many areas substantial grazing on stubble fields following grain harvest is practiced.

Deficiencies in P content of grazed forages have been known for most of the twentieth century. And in 1947 Mitchell stated that **P deficiency was the most prevalent mineral deficiency in cattle and sheep in the USA.**

In the 23 years since Mitchell's comments, the levels of P recommended as minimum nutrient requirements for beef cattle have continually been increased due to increased knowledge of factors affecting the availability of P to the beef animal.

For Saskatchewan, Milligan (1973) proposed 0.25% P levels for pregnant cows and heifers and 0.32% dietary P level for the lactating beef cow. NRC (1976) recommends 0.28% P in the ration of the lactating beef cow. Thus, the P requirement of the lactating beef cow appears to be in the range of 0.3% of the diet.

These recommendations appear to be realistic, but they raise a number of questions regarding the adequacy of forage species to meet these recommended P levels.

P CONTENT OF PASTURE SPECIES. In an early study of P contents of native prairie species, Clarke and Tisdale (1945) observed rapid declines in P content of all grass species as they matured. They suggested that by early July all species were deficient in P (average P content = 0.13%) when compared to suggested minimum requirements of 0.15% used at that time.

Kilcher (1980) observed a similar pattern of P content decline in pure stands of native grass species. He found that highest P contents (0.19% P) occurred about the end of June. Data of Lawrence (1978) for 30 species of grasses indicated similar trends.

A summary of the Lawrence data in **Table 1** includes several wheatgrass and ryegrass species which are recommended or show potential as introduced species for western Canada.

The wheatgrasses generally decreased more rapidly in P content than did the ryegrasses, except for slender wheatgrass, while the two potential introductions *Elymus virginicus* and *Elymus sibericus* maintained higher P levels later in the season than did the recommended varieties.

But at no time during the year did any of the grasses meet the currently suggested P requirements of 0.28-0.32% P for optimum production of the lactating cow.

CONSEQUENCES OF P DEFICIENCY with Grazing Ruminants. Classical symptoms of P deficiency such as rickets or other skeletal abnormalities are not usually of great concern with the grazing

Table 1. Seasonal Effects Upon P Content of Recommended Grass Cultivars

	Spring	Summer	Late Summer	Fall	Next Spring
Crested wheatgrass	0.219	.153	.080	.052	.030
Tall wheatgrass	0.186	.160	.095	.062	.041
Intermediate wheatgrass	0.209	.158	.090	.068	.054
Slender wheatgrass	0.226	.169	.113	.081	.064
Russian wild ryegrass	.197	.160	.098	.073	.060
Altai wild ryegrass	.199	.172	.120	.084	.063
Elymus virginicus	.216	.188	.148	.126	.116
Elymus sibericus	.252	.240	.171	.158	.132

From Lawrence, T. 1978. Can. J. Plant Sci. 58: 107.

ruminant.

Of greater importance in grazing systems are the rather subtle symptoms of P deficiency which result in decreased animal performance. Along with reduced blood levels of P (< 5 mg/100 ml inorganic P), feed intake and gain rate are depressed and decreases in milk production and reproductive failure may occur.

Early western Canadian work by Clarke and Tisdale (1945) suggested that poor calf crops and reproductive disturbances in range cattle were a result of low P contents of grazed forages.

Taylor *et al* (1976), in a 9-year study, **increased first service conception rates of beef cows from 59% to 89% and increased milk production 11% by increasing the dietary P level from 0.2% to 0.29%. Under their conditions, the supplementation with P returned $3.00 for every $1.00 spent.**

McGinty (1971) reduced postpartum anestrus of cows from 59 to 47 days by doubling the P content of the diet from the NRC requirement recommendation.

Other workers have shown increases in feed efficiency of both cattle and sheep (Beeson *et al* 1944); Webb *et al* 1975). And cellulose digestion in the rumen has been observed to increase following supplementation with P (Hall *et al* 1961).

INCREASING P ADEQUACY of the Grazing Ruminant. Since low P levels in "naturally" growing grass species appear universal, means for improving the P status of the animal should be investigated.

Application of P fertilizer has resulted in marked increases in P content for crested wheatgrass, bromegrass, and native species (Clarke and Tisdale 1945; Willis and Harrington 1940). But in view of the increases in suggested requirements for P by the animal, low fertilizer rates may be a limited benefit.

Leyshon and Kilcher of this research station (1978) were able to increase P concentration of crested wheatgrass, Russian wild ryegrass, and native grasses to very high levels following application of P levels exceeding 500 lb/acre.

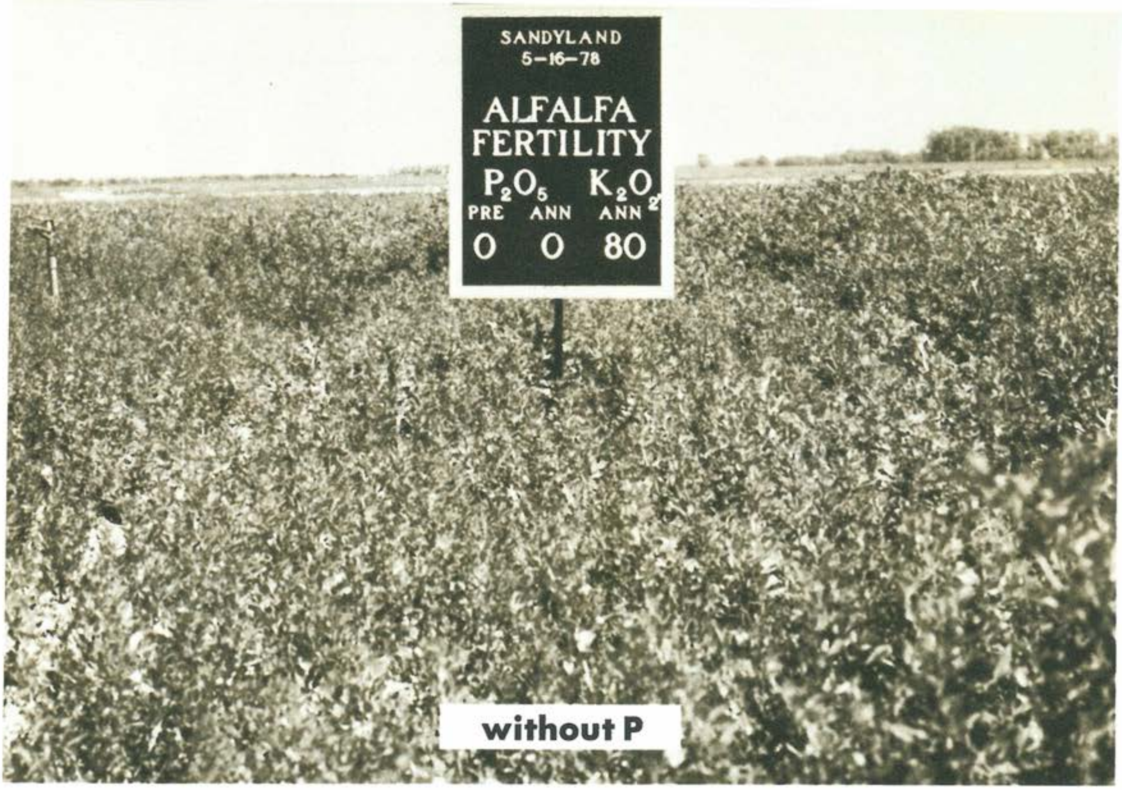
It is noteworthy that P concentrations of over 0.50 percent were obtained in Russian wild ryegrass while the levels in crested wheatgrass were intermediate between those of native grasses and Russian wild ryegrass. The economic feasibility of this approach is questionable, however, unless a substantial yield increase also resulted.

Of more practical significance at this time is the provision of a P supplement on a free choice basis to animals during the grazing season. But a number of problems are also associated with this approach. They center around ensuring animal intake of the supplement. Further investigation of supplementation systems is required.

Available information in western Canada suggests that a yearly average of cows producing calves is in the 60 to 70% range. At the same time, many producers are routinely weaning 80 to 90% calf crops.

Of these "elite" producers, almost without exception, some form of P supplementation is practiced.

It would appear, therefore, that **a major increase in ruminant production on pastures and ranges in western Canada is possible through the use of P supplementation. The End.**



Top Management of Irrigated Alfalfa Produces Top Yields

ALFALFA IS A high yielding, high quality, perennial forage. Yields exceeding 11 tons of forage and 4,000 pounds of crude protein per acre are being obtained in a Kansas State University study in south-central Kansas **(Table 1).**

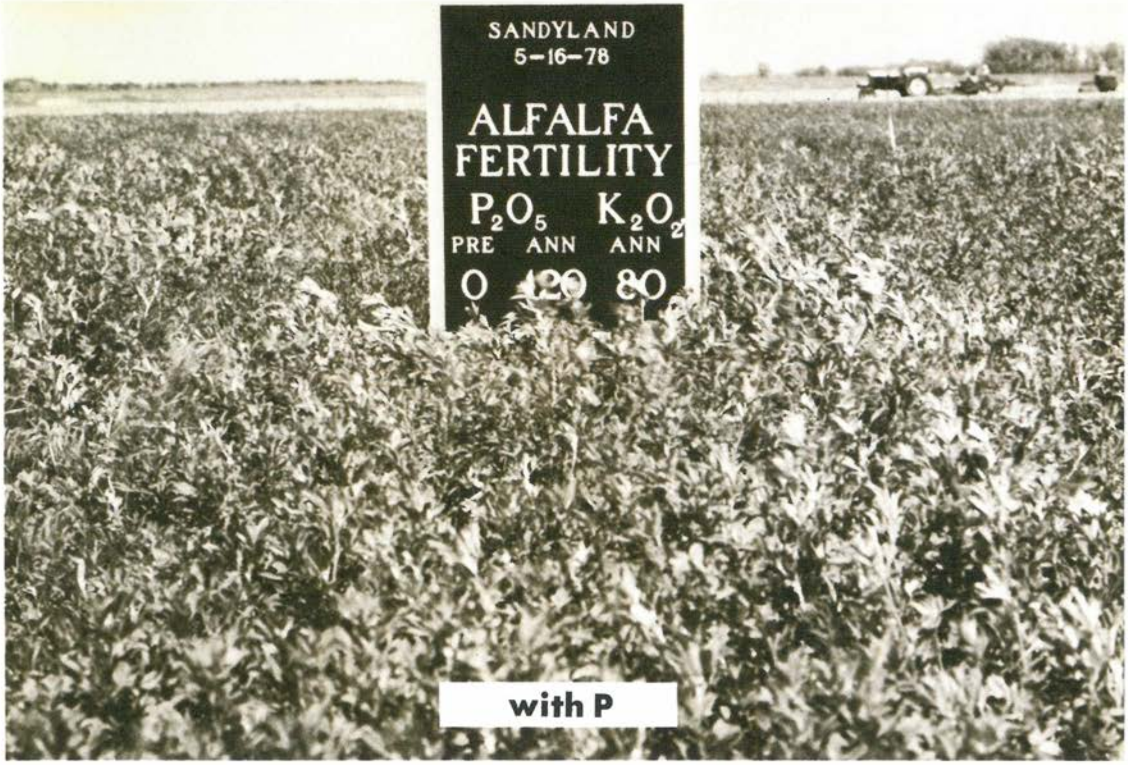
But alfalfa removes plant nutrients from soil in large quantities—up to 64 pounds of phosphorus per acre (147 lbs/a P_2O_5) and 500 pounds of potassium per acre (602 lbs/a K_2O) annually (Table 2).

Several management factors contribute to high alfalfa yields. One of the most important is variety. The variety chosen must have a high yield potential like the Kanza variety in the Kansas study **(Table 3).** Time of cutting also is important in yield **(Table 4).**

The first cutting in south-central Kansas should be about mid-May, varying somewhat with early or late initiation of spring growth. From the first cutting on, the crop reaches 1/10 bloom about every 28 to 30 days, so five cuttings are usual with a sixth cutting possible in some years.

But the first cutting should not be too early or it depletes root reserves. On the other hand, late cutting clips off regrowth for the next cutting. So cutting either too early or too late slows regrowth for the next cutting and reduces yield.

ANOTHER HIGH-YIELD FACTOR is minimized harvest loss. Leaves lost during harvest reduce both the quantity and quality of the crop. Because much of the crude protein is in the leaves, every effort



JAMES BALL & GEORGE TENEYCK
Sandyland Experiment Field
Kansas State University

should be made to save all material that is cut.

Irrigation has increased the acreage of alfalfa in south-central Kansas tremendously. Water needed depends on the weather. As much as 7 acre-inches have been needed to produce one cutting. That amount usually is a combination of rainfall and irrigation.

Proper timing of irrigations can also help control summer annual grasses. Watering two to three days before harvest on sandy soils allows the topsoil to dry out at harvest so weed seeds are less likely to germinate before alfalfa regrowth has a chance to shade the soil surface and retard weed growth. Also watering just before harvest assures moisture for rapid regrowth.

PROPER FERTILIZATION, of course is highly important for top yields. The initial soil test values for the alfalfa management study at the Sandyland Experiment Field were:

pH	P lbs/a	K lbs/a
7.2	18	259

Those amounts of plant nutrients in the soil are not enough for maximum yields. More P_2O_5 and K_2O are needed.

Even though the soil test results show alfalfa should respond to potassium fertilizer, there has been no response to date to applications up to 160 lbs/a K_2O annually. But annual soil tests on plots where no potassium has been applied show much less exchangeable potassium (about 90 lbs/a) in the soil than when soil tests were taken before the study was initiated.

Apparently the mineralogy of the sandy soil of the test site has been releasing enough potassium to supply the high yielding alfalfa so far. Also, soil tests taken at different times of the year are not strictly comparable on this sand suggesting winter release of K.

Response to applied P_2O_5 has been tremendous. 120 lbs/a P_2O_5 have produced the highest yields and have increased the P soil test slightly.

Soil tests indicate that 80 lbs/a of P_2O_5 applied annually maintains P content of the soil. Less than 80 lbs/a P_2O_5 has lowered soil available P levels.

Split applications of 80 lbs/a P_2O_5, 40 lbs early spring and 40 lbs after the third cutting, have shown no benefit over single 80 lb P_2O_5 applications once each year.

One of the treatments studied was 320 lbs/a P_2O_5 applied once before the study started—before alfalfa was seeded. Other treatments have included the heavy initial preplant applications plus annual applications of P_2O_5.

Yields from plots receiving no annual P_2O_5 but receiving 320 lbs/a P_2O_5 preplant yielded significantly less in 1978 and '79 than plots receiving annual 120 lbs/a P_2O_5 applications. See **Figure 1.**

Highest yields have resulted from an additional late fall cutting, after frost, on the high P treatment areas. Removal of fall regrowth has not been detrimental to the alfalfa to date.

With increasing costs of production, producers must project individual costs to determine profitability of alfalfa production. Markets vary depending on the weather and prices of other sources of protein.

Prices have ranged from $30.00 to

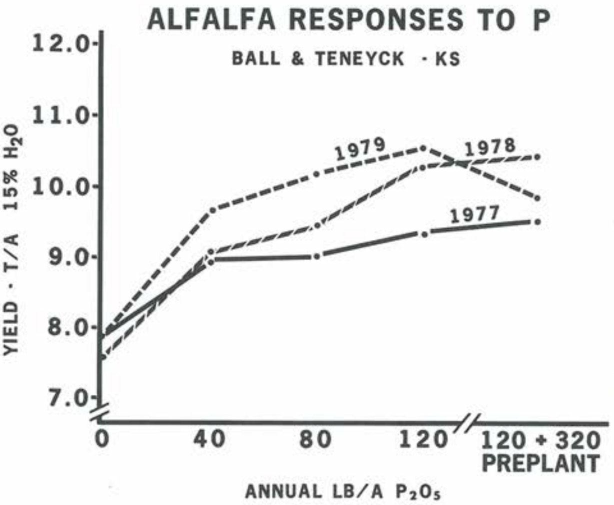


FIGURE 1

$65.00 per ton during a marketing year in central Kansas. So far, our yields have been high enough to make alfalfa production profitable at those prices.

IN SUMMARY, management tips for top alfalfa yield include selection of a variety with high yield potential, harvesting at the proper time, minimizing harvest losses, irrigating when needed, and proper fertilization.

The forage yields, crude protein yield, nutrient removal, and soil test data from our study are shown in Table 1. **The End**

Table 1—High Yield Irrigated Alfalfa—Kansas

Fertilization, lb/a			Kanza variety					
P_2O_5		K_2O	Yield*, T/A			Protein, lb/a		
Preplant	Annual	Annual	1977	1978	1979	1977	1978	1979
0	0	0	8.1	7.7	8.9	3040	2718	3503
0	40	80	9.3	9.3	10.0	3585	3266	3831
0	80	80	9.3	9.7	10.6	3566	3466	4270
0	120	80	9.6	10.6	11.0	3732	3858	4416
0	120	0	9.6	10.5	10.5	3779	3907	4371
0	120	160	10.0	10.6	11.5	3752	3799	4495
320	0	80	9.4	9.9	10.0	3613	3623	4160
320	120	80	9.8	10.6	10.6	3723	3803	4342
320	120	80**	9.6	11.6	11.3	3635	4081	4459

*15 percent H_2O, average all cuttings (5).

**Additional cutting in late fall.

Table 2—High Yield Irrigated Alfalfa Nutrient Removal, 1979

Fertilization, lb/a			Yield, T/A	Nutrient removal, lb/a				
P_2O_5		K_2O						
Preplant	Annual	Annual	15% H_2O	N	P	P_2O_5	K	K_2O
0	0	0	8.9	561	38	87	352	424
0	40	80	10.0	613	42	97	388	467
0	80	80	10.6	683	52	120	428	516
0	120	80	11.0	707	59	136	438	528
0	120	0	10.5	699	63	146	373	449
0	120	160	11.5	719	62	141	441	531
320	0	80	10.0	666	49	121	398	479
320	120	80	10.6	695	63	146	426	513
320	120	80**	11.3	714	64	147	428	516

**Additional late season cutting, Kanza variety.

Table 3—Alfalfa Variety Affects Yield, 1979

Fertilization, lb/a			Yield, T/A			
P_2O_5		K_2O	0.1 Bloom		Full Bloom	
Preplant	Annual	Annual	Kanza	Marathon	Kanza	Marathon
0	0	0	8.9	7.4	6.4	6.8
0	40	80	10.0	9.8	8.4	7.3
0	80	80	10.6	10.3	8.9	9.0
0	120	80	11.0	10.6	9.6	8.8
0	120	0	10.5	10.0	9.4	8.8
0	120	160	11.5	10.3	9.2	8.5
320	0	80	10.0	9.8	8.4	7.6
320	120	80	10.6	9.7	9.0	8.6
320	120	80**	11.3	10.8	10.4	10.3

**Additional late season cutting.

Table 4—Cutting Date Affects Alfalfa Yield and Nutrient Removal, 1979

Fertilization, lb/a			Yield, T/A 15% H_2O			K Removal, lb/a		
P_2O_5		K_2O						
Preplant	Annual	Annual	0.1 Bloom	Bud	Full Bloom	0.1 Bloom	Bud	Full Bloom
0	0	0	8.9	7.0	6.4	352	268	237
0	40	80	10.0	8.4	8.4	388	333	353
0	80	80	10.6	9.1	8.9	428	337	354
0	120	80	11.0	9.6	9.6	438	374	376
0	120	0	10.5	9.0	9.4	373	349	345
0	120	160	11.5	9.1	9.2	441	339	410
320	0	80	10.0	8.7	8.4	398	354	387
320	120	80	10.6	9.0	9.0	426	366	361
320	120	80**	11.3	10.0	10.4	428	353	423

Physiological Considerations When Managing Alfalfa for Maximum Yields

D. A. MILLER
University of Illinois

MANAGEMENT OF ALFALFA involves much more than just harvesting and fertilizing the crop.

Still, most producers could improve their alfalfa production by merely timely harvests and more adequate fertilization. Presently approximately 95 to 100% of the corn producers fertilize their corn crop, **while 15 to 50% of the producers fertilize their forage crops and only 5 to 15% fertilize their pastures.**

This one practice, **adequate fertilization,** would greatly increase alfalfa production and maintain a much more productive stand for longer periods of establishment.

Management of alfalfa includes: **field selection, cultivar selection, fertilization, inoculation, seeding rate, seedbed preparation, weed and insect control, timely harvest, rest periods, fall management,** and **proper harvesting methods.**

Many producers already know many of the proper agronomic practices involved with good alfalfa establishment. Those very familiar practices are multi-pest cultivar selection, inoculation, seeding rate, seedbed preparation, and weed control.

ESTABLISHMENT. One might review a very simple step in alfalfa establishment, the effect of previous crop. It has been shown that when alfalfa is seeded where alfalfa was grown the previous year, yields decline over the years **(Table 1).** In contrast, when planted after corn or soybeans, alfalfa yields are higher.

Table 1. Annual dry matter yield and stand counts of alfalfa the 6th year of various cropping sequences, Urbana, IL

Rotation (for 6 years)	Metric tons D.M./ha	Plants/m_2
Corn-alfalfa	8.5	49.2
Corn-soybean-alfalfa	7.8	41.0
Alfalfa-alfalfa	4.3	21.3

If the previous crop was properly managed, such as not applying too much herbicide, one will obtain higher dry matter yields when alfalfa follows corn. This is accounted for, in part, by the large number of plants per unit area **(Table 1).**

The present thought is that alfalfa releases a water soluble chemical that inhibits alfalfa establishment and growth. Therefore, select a field which was not in alfalfa the preceding year.

One cannot overemphasize the importance of proper fertilization for alfalfa production and maintenance of a healthy stand.

In the past we have thought that for every ton of dry matter production, alfalfa removes approximately 12 lbs of P_2O_5 and 60 lbs of K_2O. Recent findings in Pennsylvania have shown over a 3-year period, using the top 20% of the hay producers studied, an average of 14 lbs of P_2O_5 and 66 lbs of K_2O was removed in each ton.

We must maintain the P and K tests in our soils at around 45 and 400, respectively. Therefore, one must increase the amount of fertilizer that is annually applied according to the total amount removed.

For high quality forage, alfalfa should be harvested at the late bud to first bloom in the early spring with subsequent harvests every 30 to 35 days. **High fertility will provide the root reserves for rapid, uniform regrowth.**

As one harvests alfalfa at a younger stage of growth, bud to prebloom, the % K removed in the forage is higher **(Figure 1).**

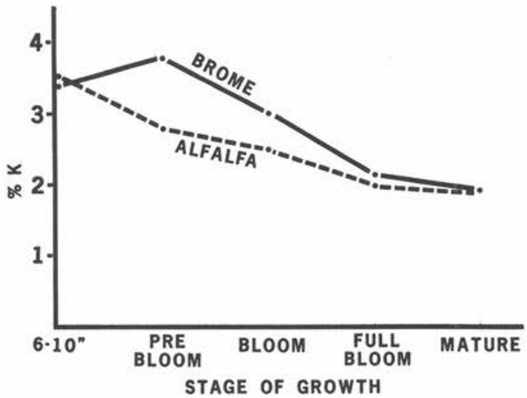


FIGURE 1—Va.

CUTTING HEIGHT. Growers sometimes argue over the recommended cutting height. From a physiological and morphological point of view, it is recommended to harvest at a low stubble height, around 1½ to 2″ instead of a taller height of 4 to 5″ **(Figure 2).**

The crownal buds or sites of regrowth are located at or slightly below the soil surface **(Figure 3).**

Cutting close to the soil surface, all of the top growth, which may possess some diseases or insects, is removed. This helps reduce the build-up of such diseases or insects. It is just good sanitation to remove all of the top growth.

If harvested at a height of 4 to 5″, regrowth will be more uneven and will develop from axillary buds on the remaining stem-stubble.

CUTTING FREQUENCY AND ROOT RESERVES. Soluble carbohydrates or food reserves are stored in the crown and taproot of alfalfa. It has been found that the soluble carbohydrates are produced, stored and used in a cyclic manner which is accelerated by cutting **(Figure 4).**

When growth begins in early spring, food reserves are depleted until the top growth is around 6 to 8″ and then soluble carbohydrates are again translocated from the tops to the crown and taproot **(Figure 5).**

For high yielding alfalfa where 4 or 5 cuttings are taken, it is very important to

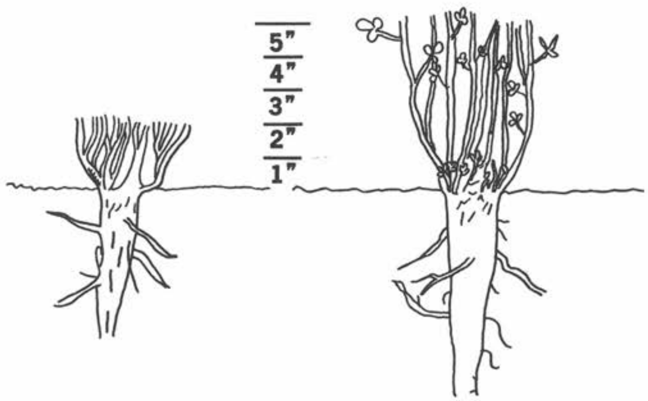


FIGURE 2—Cutting height

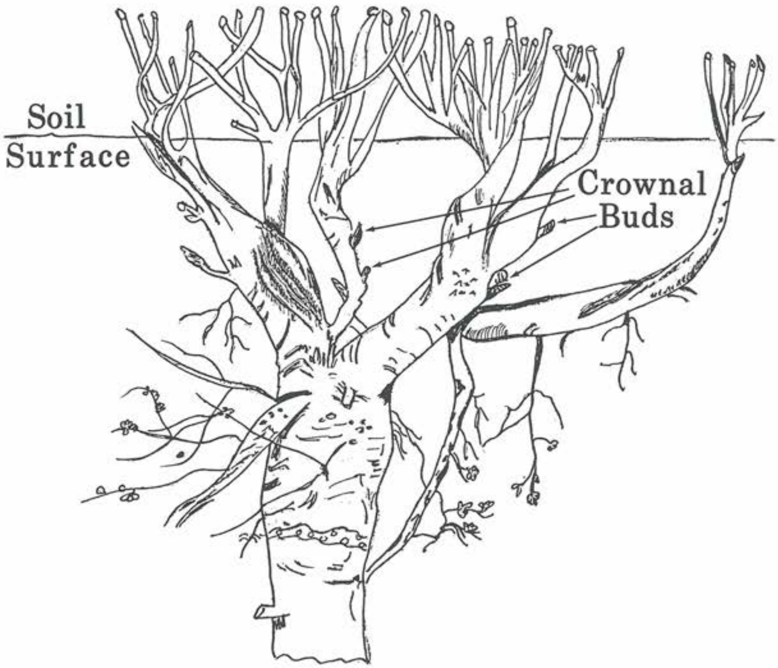


FIGURE 3—An older crown of alfalfa

manage alfalfa so that the food reserves are at the optimum level. Or sufficiently high enough to allow rapid regrowth after harvest. Adequate fertility is a key component for rapid regrowth and food reserve production.

WINTER SURVIVAL. The last harvest in the fall should occur around 35 to 40 days before the average killing frost. The reason for this practice is to allow enough growth to occur again so that the soluble carbohydrates are built back up for excellent winter survival.

If the alfalfa plant has only one or two weeks of growth after the last harvest, the plant is still using up its previous food reserves to regenerate new growth. A killing frost at this stage means no food reserves for winter survival and death will occur and/or considerable spring heaving may occur due to poor or weak root structure.

Many of our present day cultivars con-

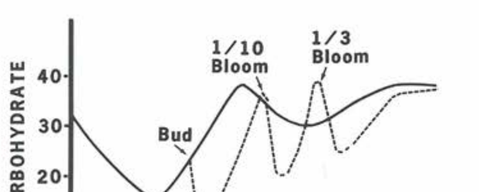


Figure 4. Seasonal trends of total available carbohydrates in roots of Vernal alfalfa under a 3-cutting scheme and without cutting.

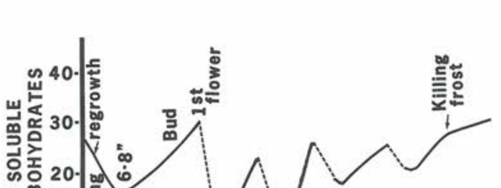


Figure 5. Influence of a cutting sequence for maximum yields (5 cuts) on soluble carbohydrates in alfalfa roots—Illinois.

tinue to grow during the fall after the September harvest. In other words they have very little fall dormancy. Many researchers believe that one needs fall dormancy for excellent winter survival. This may be debatable.

In any case, if one has at least a one-year-old excellent stand of alfalfa that is well fertilized on a well drained soil and it continues to grow until a killing frost, one may take a late harvest (*after the killing frost*). The management exception here would be the cutting height.

In contrast to the earlier harvests, this last fall harvest should be cut at a higher stubble height, around 4" to 5".

The purpose for this recommendation is threefold: **(1) leaves some winter insulation, (2) helps collect snow cover,** and **(3) prevents icing over in the spring.** Ice sheets generally do not "climb" that high over plants. Thereby small penetrations of stems protrude through the ice, allowing for air exchange, which prevents smothering of the plants.

The late fall harvest aids in removing egg laying sites for the alfalfa weevil or overwintering protection for other insects. It is also a food sanitation practice in that it lowers the incidence of disease build-up.

SUMMARY. All in all there is much more to planting, fertilizing and harvesting alfalfa than the procedure itself. Each step in the management of alfalfa has many physiological effects.

Just keep in mind that the alfalfa plant is a perennial plant—meaning that we must not only manage or maintain it during the growing season, but we must manage it for proper winter survival. **The End**

N & P: PARTNERS IN EFFICIENCY

HIGH YIELDS per acre and efficient production are the farmer's main weapons against inflated farming costs.

Applying nutrients based on **sound research** and properly **correlated soil tests** at high yield levels return the farmer highest profits on his fertilizer investment.

Applying nitrogen **without adequate phosphorus** may increase yield some—but will not get nearly the yield out of nitrogen that more phosphorus will help bring.

A Kansas corn study showed how phosphorus can help corn get the most out of nitrogen. It began in 1961 with up to 200 lb N per acre. Phosphorus produced **NO response the first 5 years.** Soil tests at the end of 5 years showed a steady decline in soil test P—from the **original medium level** to a **low level.** Maximum yields came from about 210 lb N per acre.

As soil tests continued to decline, P responses began to occur. Forty pounds of P_2O_5 applied pre-plant with the nitrogen improved yields as the soil's ability to supply phosphorus diminished. When the phosphorus responses started occurring, additional N increased yields up to 160 lb N/A.

By 1977, nitrogen applied **without needed P** added only 74 bushels per acre more corn, but nitrogen **with adequate phosphorus** added 122 bushels per acre. This yield increase was 48 bushels per acre—or a **NET return of $89, figuring corn at $2.00 per bushel.**

Grain sorghum yields have shown the same trend. From 1968 through 1977, limited phosphorus supply reduced yields an average of 21 bushels per acre. A convincing way to look at that difference is to say **N was 21 bushels per acre less efficient without adequate phosphorus.**

RANGE FERTILIZATION: The Role of Phosphorus

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USDA/SEA, Sidney, Montana

RANGELANDS of western United States and Canadian Prairie Provinces include over 728 million acres that produce enough forage to support about 172 million **animal unit months (AUM's)** of grazing **(Table 1).** With AUM values ranging from $4.00 to $8.00, this natural resource is very valuable and plays an important role in the region's economy.

Table 1. Land area and grazing capacity of rangelands in western United States and the Canadian Prairie Provinces (U.S. Forest Service 1972; Smoliak 1969).

Ecosystem	Acreage	Grazing Capacity (AUM)[2]
	(millions)	(millions)
Ecosystems that produced significant yield increases when fertilized		
Mountain Meadow	4.0	4.3
Mountain Grassland	79.8	21.4
Annual Grassland	6.7	7.0
Prairie	38.4	36.8
Plains Grassland		
United States	173.3	50.5
Canada[3]	43.9	14.6
Seeded Pastures		
United States	32.9	32.9
Canada	5.0	5.0
TOTAL	384.0	172.5
Other	344.4	28.8
TOTAL	728.4	201.3

[2]Animal unit months.

[3]Includes small amounts of prairie and wooded grasslands.

Small changes in per unit production become significant when applied to large segments of this acreage. Over half the rangeland area and about 85% of the total production is included in ecosystems which have produced significant forage and livestock responses when fertilized.

Despite a demonstrated potential to increase production, range fertilization is not a widely accepted tool. For example, a recent survey of 20 counties in eastern Montana and western North Dakota indicated that only 1.2% of the native range and 9.5% of the introduced dryland pastures had ever been fertilized (Wight 1976).

Economic constraints, fear of adverse effects of fertilization on native ecosystems, and reluctance to implement the grazing management necessitated by fertilization have been the main deterrents to range fertilization.

NITROGEN is the most deficient nutrient on rangelands. Yield responses to N are primarily a function of the available soil water supply **(Figure 1)** and vary with climate, site characteristics, and N-rate **(Figure 2).** Within ecosystems that respond to N fertilization, yield increases of 50 to 200% are common.

With the possible exception of some mountain meadows, annual N rates of 25 to 50 lb/acre or their equivalent applied biennially or triennially have been sufficient to optimize N-use efficiency (pounds dry matter produced per pound of fertilizer N).

Phosphorus (P) deficiencies on rangeland are, with few exceptions, secondary to N deficiencies, and yield responses are usually associated with N fertilization (Johnston et al 1968; Wight and Black 1979). The exceptions include legume fertilization and soils severely deficient in available P.

On sites where seeded grasses or native range respond to P without N fertilization, the yield response is usually very small. For example, annual applications of 18 and 36 lb P/acre increased average annual forage production 16 and 29%, respectively, on a mixed prairie range site in North Dakota regardless of the N treatment (Lorenz and Rogler 1972). However, the 29% increase represented only 182 lb forage/acre on the zero-N treatment, whereas it represented 668 lb forage/acre on the 80 lb N/acre/year treatment.

As N becomes nonlimiting, yield responses to P increase significantly **(Figure 3). The N-P interaction depicted in Figure 3, is typical for most fertilized rangelands.** Whereas the potential yield increase varies among sites, the 20 to 25% increase, represented in Figure 3, is probably about average.

AN IMPORTANT ASPECT of P fertilization is the **improvement of forage quality.** During most of the year, P content of range forage is below the minimum nutritional requirement for beef animals and P must be supplied through a supplementation program. Nitrogen fertilization further decreases the P content of range forage through the dilution effect of increased forage yields.

This adverse effect of N fertilization on forage P content can be offset by P fertilization. While P fertilization can significantly increase forage P content, the amount of increase is directly related to site conditions and P rate. Black (1968) found that single applications of 40 lb P/acre or less increased the average P content of mature crested wheatgrass **(Agropyron cristatum)** and native range grasses 34 and 24%, respectively, over a 4-year period. The increased P levels, however, were still below the 0.18% recommended as the minimum required for all beef cow diets except high energy finishing diets which require 0.22% P (National Research Council 1976).

On a similar site a single application of 100 lb P/acre increased the average P content of mature native grasses to about 0.20% as measured over an 8-year period (Black and Wight 1979). While improved P content alone may not economically justify applying P fertilizers, it is an important aspect of range fertilization and should be considered in making economic evaluation of proposed fertilizer treatments.

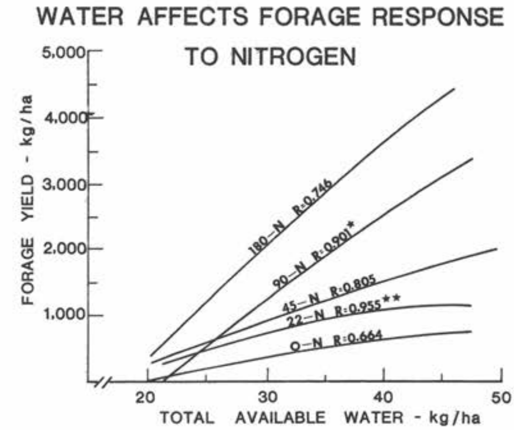

Fig. 1. Effects of available water on native grass forage production with different rates of N fertilizer applied annually (Smika et al 1965).

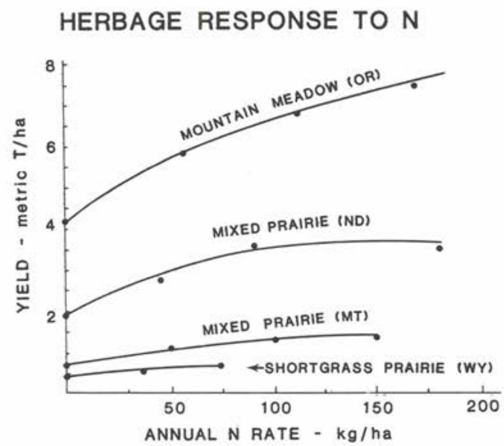

Fig. 2. Herbage response to N in four divergent grassland plant communities (Mountain Meadow-Nelson and Castle 1958; North Dakota Mixed Prairie-Lorenz and Rogler 1972; Montana Mixed Prairie-Houlton, 1975; Shortgrass Prairie-Rauzi unpublished data).

ANNUAL P UPTAKE by native range plants is relatively small. Black and Wight (1979) reported that annual P uptake in aboveground plant material averaged 1.4 lb/acre in an unfertilized system and only 3.7 lb/acre when both N and P were ade-

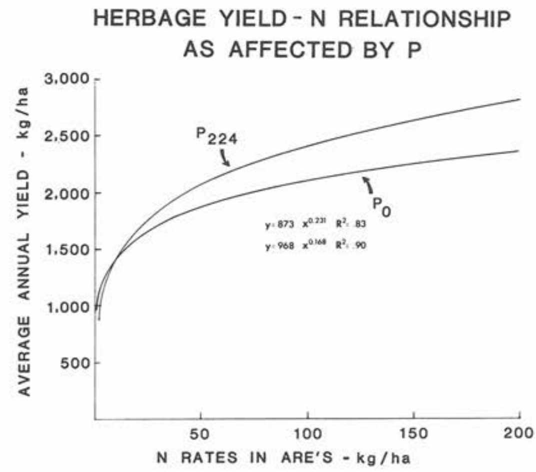

Fig. 3. The herbage yield N relationship as affected by P (Wight and Black 1979).

quate. Despite small annual P requirements, relatively high P rates are required to ensure a full P response.

This is due to the immobility of surface broadcast P fertilizer and P immobilization within the soil-root system. Black and Wight (1979) estimated that up to 6.9 lb P/acre could be immobilized in the root biomass. If fertilizer P could be incorporated into the soil, low-rate P applications would probably be more efficient, and this is possible when establishing seeded pastures.

Because annual P requirements are so small, the residual effects are great. On a glacial till soil in eastern Montana, Black and Wight (1979) estimated that residual effects of 200 lb P/acre would last up to 76 years when N was adequate and up to 738 years when rangeland was not N fertilized.

Unlike N, P fertilization normally does not greatly influence species composition, although forbs and shrubs usually respond more to P than do grasses. With high rates of N (300 lb/acre or more), P may, under some conditions, promote the growth of weedy forbs such as tansy mustard **(Descurainia sophia).**

THE MAIN ROLE of P fertilization is to increase legume production, improve forage quality, and complement N fertilization programs. Under continuing N fertilization, P deficiencies will become more acute, and frequency and magnitude of P responses will increase. Good soil tests are available to measure soil P. However, grasses seem to have greater ability to utilize P from low P soils than do most cultivated crops.

More research is needed relating soil test P values to yield responses on rangelands. Economics is the controlling factor, and most fertilization decisions will be based upon projected economic returns. Such projections should include both quantity and quality responses.

AN ESTIMATE of economic returns that might be realized from the application of N and P to a mixed prairie range site in the Sidney area of Montana follows. The assumptions made in this example are noted in **Table 2:**

(1) Cost of fertilizer nutrients and application was $0.20/lb. each for N and P_2O_5.

(2) Cost of fertilizer, including interest at 10%, was amortized over the 8-year period.

(3) Yearling cattle grazed the range.

(4) Only 60% of total herbage production utilized by grazing cattle.

(5) 12 lb. of dry herbage consumed by cattle resulted in one lb. of live weight gain.

(6) Live weight gains are valued at current high levels of $0.75/lb.

Table 2

Fertilizer Applied in 1969 LB/A		Cost of Fertilizer	Herbage Yields 1969-76 Dry Matter	Value of Liveweight Gains	Return over Cost of Fertilizer	Return over No Fertilizer
N	P_2O_5	$/A	LB/A	$/A	$/A	$/A
0	0	—	7,805	293	—	—
100	0	29	11,162	418	389	96
100	230	97	10,043	377	280	—13
100	460	164	10,692	401	237	—56
300	0	88	13,279	498	410	117
300	230	156	15,995	600	444	151
300	460	223	17,794	667	444	151
900	0	264	15,546	583	319	26
900	230	332	17,029	638	306	14
900	460	399	19,124	717	318	25

As might be expected, N increased herbage yields and the estimated returns from weight gained by yearling cattle. With the exception of the low rate of N, addition of P in combination with N also increased forage production and calculated values of liveweight gains. Apparently, the low rate of N was inadequate to balance the added P.

Estimated returns were highest with the combinations of 300 lbs. of N/acre plus P. By including P with 300 lbs. of N/A, potential returns were increased by $34/A.

Although the applications of 900 lbs. of N/acre in conjunction with P produced the highest herbage yields and calculated liveweight gains estimated value of the increased beef production did not completely compensate for the greater fertilizer costs.

It is obvious that this evaluation is a rough approximation because of the difficulty in adequately treating all of the numerous factors; for example, allowances were not made for improvements in forage quality or palatability and digestibility. **The End**

Fertility Recommendations For High Yields

JAY W. JOHNSON
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UNIVERSITY AGRONOMISTS are being more frequently asked to make fertility recommendations for producing very high crop yields, such as 200+ Bu/A of corn.

But very little fertility research has been conducted at high yield levels. Can we make recommendations for yields above what has been achieved experimentally?

W. G. Cochran and G. M. Cox addressed this question in their book, **Experimental Designs,** now in its second editing by John Wiley and Sons of New York.

They said, **"Polynomials are notoriously untrustworthy when extrapolated. A polynomial surface (response curve)* should be regarded only as an approximation to within the region (yield range)* covered by the experiment. Any prediction made from the polynomial about the response outside the region should be verified by experiments before putting reliance on it."**

This is a warning against extrapolation beyond the yield range of experiments.

The basis of most of our current recommendations comes from work by Mitscherlich and Bray. Mitscherlich developed equations correlating plant growth with nutrient status.

Bray later adapted Mitscherlich's equation to allow correlation of crop yield to soil test level. The equation Bray used was:

$$\text{Log }(A\text{-}Y) = \text{Log } A - C_1 b_1 - CX$$

Where $A = 100\%$ **yield**

$Y =$ **Observe yield for nutrient status**

$C_1 =$ **Proportionality constant**

$b_1 =$ **Soil test level**

$CX =$ **Fertilizer factor**

If this equation is used without the fertilizer factor (CX), the expected yield (Y) at a given soil test level (b_1) can be calculated.

If the fertilizer factor is included, the amount of fertilizer needed to achieve 100% yield can be determined.

Bray conducted field experiments during the 1940's to determine the proportionality constant (C_1) of ammonium acetate extractable K and $Bray_2$ extractable P. His results have been used worldwide as the basis for making fertilizer recommendations from soil test results.

Bray's work has helped farmers achieve higher yields through fertilization. And his basic equations still appear to relate adequately the plant growth to the nutrient status of the soil.

But farming has changed dramatically since 1940. We must recognize problems with using Bray's data in making fertilizer recommendations for today's crops.

CHANGES IN THE PROPORTIONALITY CONSTANT has always been a problem because the accuracy of the correlation is reduced. Examples of what can change the proportionality constant are **(1) variable plowing depths, (2) moisture content of the soil, (3) soil temperature, (4) genetic changes in the plant material.**

DIFFERENT P EXTRACTANT IS USED TODAY. Bray used his P_2 extractant to measure P availability while today most labs use the Bray P_1 extractant.

For most midwest soils, it has been reported, Bray P_2 extracts about three times as much P as Bray P_1. This 3:1 ratio has been built into the recommendation procedure. But for some soils,

Approved for publication as Journal article No. 93-79 of the Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.

especially calcareous soils, this ratio is not accurate.

YIELDS ARE MUCH HIGHER TODAY. When Bray was collecting his data from 1938 to 1941, his top corn yields ranged from 40 to 103 Bu/A.

If we use his data to predict the nutrient needs for 200-bushel corn, we can be grossly wrong.

These Ohio examples prove the point:

Example 1. Soil-Wooster silt loam

Bray $P_1 = 12$

Bray's 98% yield recommendation = 18 lb P_2O_5/A

1977 yields 0 lb P_2O_5/A = 145 Bu/A

120 lb P_2O_5/A (optimum) = 179 Bu/A

Example 2. Soil-Hoytville silty clay loam

K test = 306 lb K/A

Bray's 98% yield recommendation = 0 lb K_2O/A

1977 yields 0 lb K_2O/A = 136 bu/A

600 lb K_2O/A (optimum) = 152 Bu/A

If Bray's recommendations had been used, corn yields would have been less than optimum, these examples show. Other examples from Ohio and other states have also shown this discrepancy.

FERTILIZER ALONE IS NOT THE ANSWER. Adding more fertilizer will not necessarily result in high yields. Other crop management factors must be considered to obtain response to additional fertilizer.

These factors include **variety or hybrid selection, planting date, plant population, pest control, etc.** A less than adequate job with any of these factors will lead to less than maximum response to improved fertility.

RESEARCH YIELDS MUST IMPROVE. Nowhere is optimum crop management more important than in research where fertility response is being measured.

Many of the better farmers are now producing higher crop yields than university researchers are.

If we are to make valid recommendations for 200 Bu/A corn and even higher yields later, we must achieve research yields of 200 Bu/A now, 250 Bu/A in 5 years, and 300 Bu/A in 10 years.

For soybeans the research yields should be 75 Bu/A now, 85 Bu/A in 5 years, and 95 Bu/A in 10 years. **The End** *Author's addition.

P Helps Small Grains Overcome Root Rot . . .

RAPID CROP GROWTH depends on the uptake of water and plant nutrients from the soil. Young, actively growing roots and root hairs are the major absorbers of water and plant nutrients.

Root rot organisms destroy the fine roots and root hairs of small grain crops. Root rots can cripple the crop's ability to take up the necessary quantities of moisture and plant nutrients.

Phosphorus fertilization stimulates growth at the growing points both above and below the ground. Most growing conditions need greater root development, especially when a crop's root system is being attacked by root rots.

Modest amounts of phosphorus fertilizer virtually eliminated Browning root rot of wheat in Western Canada. This disease has flared up occasionally when the routine use of phosphate fertilizer was dropped substantially.

Phosphorus fertilization has reduced infections of Take-all, a serious root rot disease in many wheat growing areas of the world.

Research at Oregon State University agrees with these previous findings. When 40 lb of P_2O_5 per acre was applied. Take-all infection declined substantially in wheat.

Common root rot is the most widespread root rot disease of barley and wheat in Western Canada. Between 24 and 50 lb of P_2O_5 per acre lowered the incidence and intensity of this disease. Phosphorus controlled common root rot infections of wheat best at mid-season.

Why phosphorus fertilizers tend to offset the detrimental effects of root rot infections in small grains is not fully understood.

One possibility may be the way phosphorus increases plant vigor. This enables crops to withstand and perhaps outgrow the infection. And P may also influence soil microorganisms directly.

Using phosphorus fertilizers in small grain production is a wise investment since P will contribute to top yields in the usual ways. Added phosphorus fertilizer also helps overcome yield-depressing attacks by root rot organisms. **The End**

Steps To Maximum Alfalfa Yields

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You can produce maximum alfalfa yields by following these ten steps.

STEP 1. Select a well drained soil.

STEP 2. Soil test.

STEP 3. Lime soil to pH 7.

Correct the soil plow zone to a pH of 7 where the subsoil is acid. Alfalfa grows best where soil pH is 6.5 or above. Correcting surface soil to pH 7 brings subsoil pH to the desired range over time. Apply lime and incorporate at least six months prior to seeding whenever possible. Table 1 shows the effect of maintaining various soil pH's in the tilled zone on the subsoil pH.

TABLE 1. Effect of liming surface soil on subsoil pH

	Soil depth Inches	Corrected and maintained pH during test				
Surface soil	0-7″	4.9	5.5	6.0	6.5	7.2
pH of subsoil after 30 years		pH at various depths resulting from surface application of limestone				
	7″-14″	4.9	5.2	5.9	6.7	7.2
	14″-21″	4.7	4.8	5.2	5.4	6.5
		Wooster silt loam				

STEP 4. Raise soil P_1 level to 90 pounds P/A and K level to 300-400 pounds K/A.

Incorporate a corrective application of phosphorus and potassium prior to seeding.

STEP 5. Use certified seed of an adapted variety.

Inoculate the seed with correct strain of inoculum.

STEP 6. Seed shallow in a firm seedbed.

Planting in a firm seedbed can reduce seeding failures. Plant seed ¼ to ½ inch deep. Fertilizer should be banded to separate it from the seed by an inch or two. The press wheels will firm the seedbed to hold moisture close to the seed insuring good germination.

STEP 7. Reduce competition to give seedlings a chance.

Don't seed with a small grain crop and use herbicides to control weeds. You can produce 3 tons/A or more when you seed only alfalfa and control weeds. Plant in early spring.

STEP 8. Control other pests, too.

High yields and stand longevity depend on your controlling weeds, the alfalfa weevil and the potato leafhopper.

STEP 9. Harvest on time.

Begin harvesting at late bud development stage to get maximum yields of high quality alfalfa. Harvest traditional varieties on a 38- to 40-day schedule after an early first cutting. You should get four cuttings before mid-September.

Harvest "flemish" types of alfalfa every 35 to 36 days. You must keep soil fertility levels high in an intensive cutting system to get high yields and to maintain stands.

If you keep potassium levels high, you can get an extra cutting in late October or early November.

STEP 10. Fertilize annually.

Alfalfa is a heavy user of phosphorus and potassium. Dry matter alfalfa hay contains approximately 0.3 percent P and 3-4 percent K. Apply 14 pounds P_2O_5 and 60 pounds K_2O per acre for each ton of alfalfa removed annually. Apply after the first cutting, in the fall or split the application between both dates.

Micronutrients such as boron and manganese are needed on some soils. As yield levels increase the demand for these nutrients also increases. **The End**

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Plant Food Your Corn Takes Up	________	$________
Alfalfa Absorbs Much Plant Food	________	$________
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Potassium for Agriculture (40 pages, 4-color)	________	$________
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