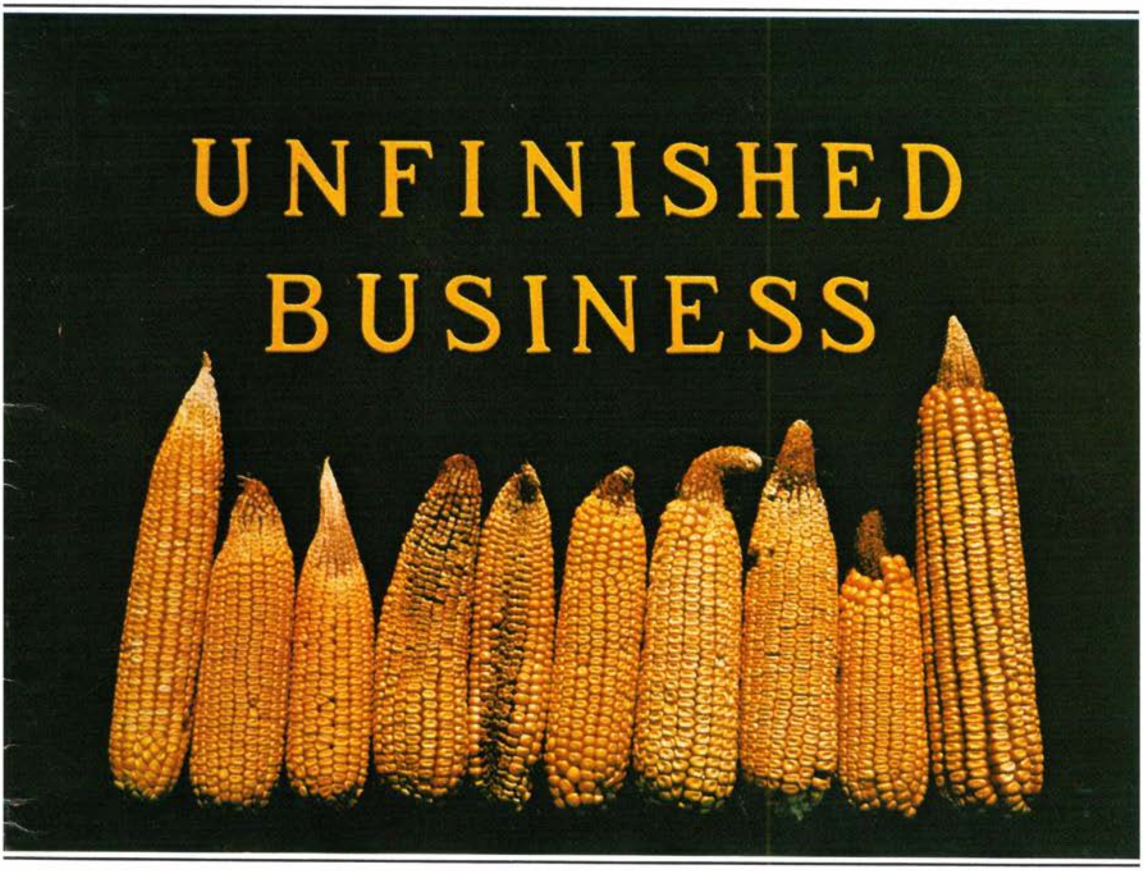
Better Crops
WITH PLANT FOOD

March—April, 1965 20 Cents



DON'T LET YOUR CROP GO OUT OF BUSINESS!

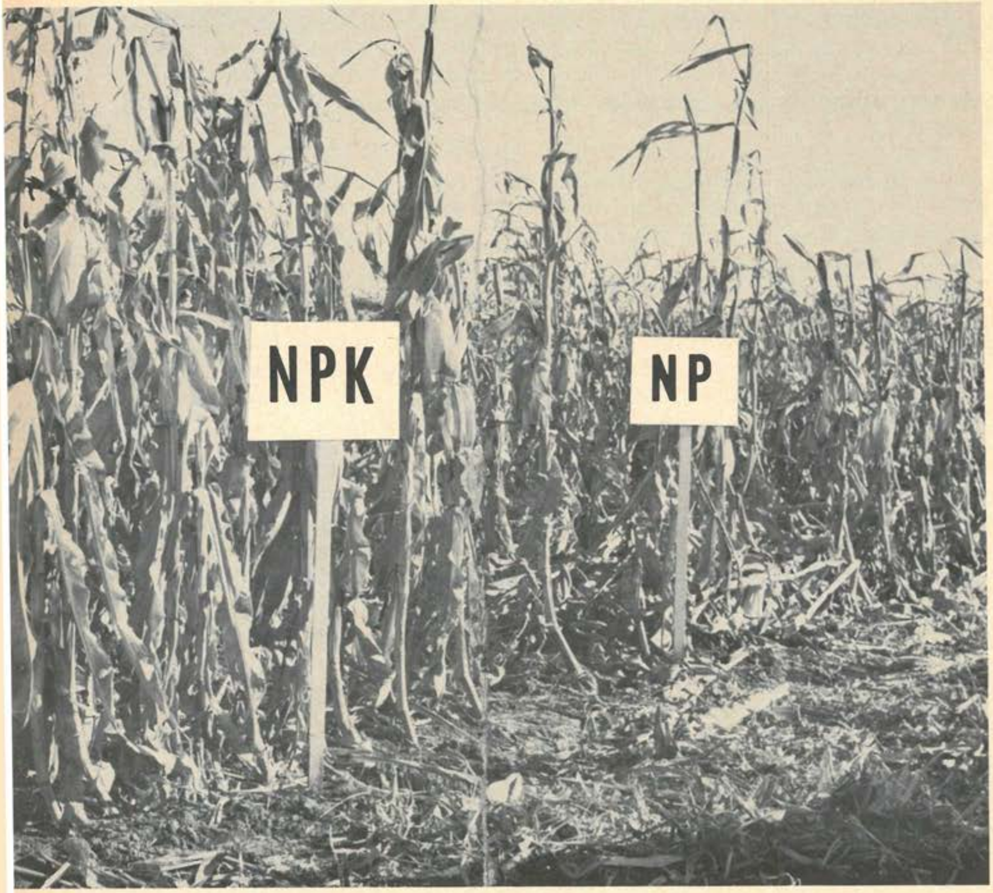
USE N-K TEAMWORK

A Special Issue

NITROGEN-POTASSIUM TEAMWORK PAYS OFF

A SPECIAL ISSUE

WE ARE STILL LEARNING to use nitrogen (N) and working to understand its relationship to other plant nutrients. In early trials with P and K, nitrogen was often the most limiting element. Today high N usage has become a major production "tool," requiring us to set new "sights" for other essential elements used in crop production. This is especially true for potassium, an important partner of nitrogen. And careful attention must also be given to soil pH changes.



97.8 bu/A

85.6 bu/A

HIGH NITROGEN CAN INCREASE THE POTASH NEEDS OF CROPS—as shown by this corn. On a soil testing "medium" in exchangeable K, the corn on right produced a fair yield, but most of it lodged. The corn on left was standing well at harvest. This points up two basic needs in high-yield farming: (1) All elements needed for crop growth should be available in proportion to the crop's need for them, (2) Factors other than yield should be carefully considered when interpreting results—especially those involving N and K. With many crops, K needs often equal or exceed nitrogen needs. In any event, today's top farmers know the importance of nitrogen-potassium teamwork in getting top profit yields.

This issue of *Better Crops Magazine,* under the chairmanship of Werner L. Nelson, features important facts on this N-K teamwork.

Hidden hunger is defined as that production level at which no deficiency symptoms can be seen, but where profitable increases from an added practice might be expected. The best insurance is to keep the chemical machinery *within* the plant working at top efficiency throughout the growing season.

Plant breeders have developed plants capable of high yields. The farmer's job is to eliminate factors that restrict yield, creating conditions which enable the improved varieties to produce to the fullest. His tools for accomplishing this job have improved each year until the challenge facing today's leading farmers is near the *top of the yield curve*. For these farmers, stunted growth and visible deficiency symptoms are seldom seen. It is the "hidden hunger era."

In recent years, agronomists, plant physiologists, and biochemists have developed a better understanding of chemical reactions in a plant.

They have found that a *balanced and adequate supply of plant food is essential for efficient operation at high production levels.*

N-K BALANCE VITAL

The ability of plants to use non-living inorganic minerals in producing living organic compounds is a great miracle of life. At least 16 inorganic elements have been found necessary—comparatively large amounts of some, only a trace of others. Each plays a vital role. Two of the major nutrients are nitrogen and potassium. Studied intensively, both have been found essential for several reasons.

Nitrogen becomes a part of the framework of many organic compounds. Unlike other nutrients, potassium is not known to become a part of organic compounds. Yet, it is vital in forming these compounds and important in keeping chemical reaction cycles from being disrupted.

N-K balance is perhaps the most important consideration. Research has shown that N-K imbalances contribute to lodging, to winterkill, to disease

N-K BALANCE

incidence, to poor or inferior quality of grains, fruits and forages—and most important, *it limits top yields!* Each of these factors typifies the "hidden hunger era." The model on page 5 may help us understand the influence of N and K.

Each numbered process in the model depends on the efficient operation of other steps, creating a continuous cycle. Complete chemical structures are omitted in the figure—only the number of carbon (C) units are shown.

1 THE SOIL—TO SUPPLY NUTRIENTS AND WATER. Plants rely on the soil to provide nutrients and water. When water is absorbed through the roots and combined with CO_2 from the air and energy from sunlight, the miracle of plant life begins. To prevent hidden hunger, the first job is to insure

BY
W. K.
GRIFFITH

AMERICAN
POTASH
INSTITUTE

IN A HIDDEN HUNGER ERA

an adequate nutrient supply. But the key to success still lies with the plant's ability to utilize these nutrients efficiently.

2 PHOTOSYNTHESIS—THE BUILDING PHASE. The basic building block of all organic compounds is carbon (C). This element must come from CO_2 in the air. Photosynthesis is the process that accomplishes the job: the combining of CO_2, water, and energy from sunlight in the presence of chlorophyll, the green color of plants. This occurs mainly in the leaves and is the initial building phase in plant processes.

Nitrogen is important to this process because it is an important part of chlorophyll. Note the darker green color in plants fertilized with nitrogen.

Potassium influences the size and number of *leaf cells*—the site of photosynthesis. Research has also shown that CO_2 uptake and potassium supply are connected in some manner.

3 SUGARS—THE BUILDING BLOCKS FOR PLANT FOOD AND CELL FRAMEWORK. Each unit of CO_2 captured in photosynthesis is added to a five carbon (C_5) compound in the plant. This forms a six carbon (C_6) compound—the simplest form of sugar. From these six carbon sugars, all other compounds necessary for plant life are formed. During the building processes, these six carbon units are combined into larger units. Depending on the type and number combined, framework and fiber, stored, and reserve sugar compounds are formed.

Potassium aids in sugar formation and also promotes translocation of these sugars when used for energy, for storage in seeds and tubers, and for cell wall framework. So, potassium is related to cellulose buildup and less lodging, to starch formation in grains and tubers, to percent sucrose in sugar cane and beets, and to reserve sugar supplies in grasses, legumes, trees, and shrubs to aid regrowth after clipping and to withstand winter injury.

4 RESPIRATION—THE ENERGY PRODUCING PROCESS TO DRIVE THE PLANT MACHINERY AND TO BUILD OTHER COMPOUNDS. Sugars formed in the building process are used as food for the plant in respiration—the energy producing phase. Here C_2 sugar fragments are combusted, producing energy and liberating CO_2 back to the atmosphere. This energy is used to drive reactions within the plant and to form other compounds necessary to plant growth. Plants thus have the unique ability to "recharge their own batteries" by producing power during respiration.

Potassium helps serve as a respiration regulator. Probably through its effect on sugar translocation, potassium prevents respiration from becoming so rapid it burns up excess sugar in the process.

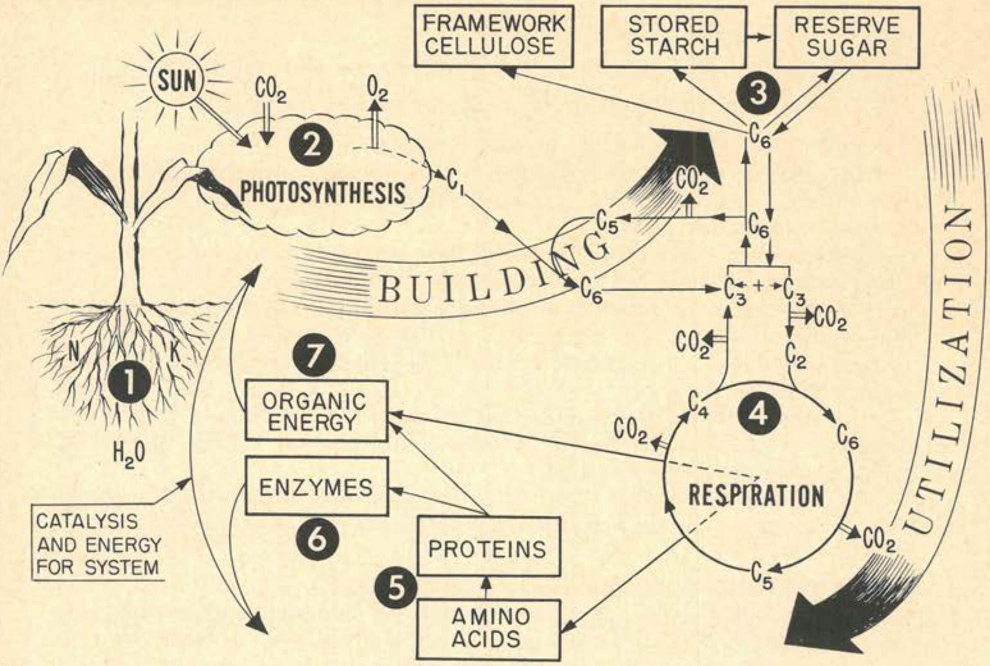
5 AMINO ACIDS AND PROTEINS—THE BUILDING BLOCKS FOR LIVING PROTOPLASM. Twenty-two amino acids make up the building blocks for protein. Fitted together in hundreds of ways, the amino acids form countless protein compounds. Proteins and protein-like compounds are closely associated with living protoplasm and growth. Enzymes, auxins, vitamins, organic energy, and many of the other compounds all have proteins in their structure. Amino acids and proteins are formed from compounds produced during respiration.

Nitrogen is an essential part of every amino acid. Therefore, it plays a key role in synthesis of these compounds. When nitrogen is limiting, the ability of the plant to function normally is greatly restricted. Potassium aids protein production. Research, especially with grasses, has shown that with adequate nitrogen but with low potassium, protein formation is retarded and there is a build-up of non-protein-nitrogen compounds which are not readily utilized by the plant.

6 ENZYMES—COMPOUNDS WHICH SPEED UP CHEMICAL REACTIONS. In general, there is a specific enzyme for every chemical reaction in the plant. Enzymes act as catalysts in aiding and speeding up these reactions. Like fusion welding, they add nothing to a compound but only aid in transforming building blocks into useful compounds.

Protein makes up a portion of every enzyme—so nitrogen is involved in enzyme synthesis and work. Certain enzymes require potassium before they operate.

Chemical Reactions in the Plant*



⟹ *Indicates to or from atmosphere*

* **Simplified Schematic of Plant Metabolism** . . . for simplicity, many pathways, intermediate steps and products have been omitted. Complete chemical structures are omitted; only the number of carbon (c) units involved are shown.

7 ORGANIC ENERGY—THE SOURCE OF POWER. Through combustion of sugars in respiration, energy is trapped and later released and utilized through organic energy compounds. These compounds give energy to certain reactions in the cycle, creating energy gradients. Chemical reactions take place as these gradients are equalized. Certain key reactions require both an enzyme and a source of organic energy.

Nucleic acids, basic units of energy rich compounds, contain nitrogen in their structures. Therefore, nitrogen is closely associated with the energy phase of plant processes. Recent research has also found that potassium may play a role forming these compounds.

OTHER COMPOUNDS

Many pathways, intermediate steps, and compounds formed have been omitted from this discussion. Lignin, fats, oils, etc. are all important and fit into the cycle. Also, other nutrients are essential. And like nitrogen and potassium, they must be available in adequate amounts for top production.

HIDDEN HUNGER CAN BE PREVENTED!

High yield farmers may well find some answers to hidden hunger problems in these three facts of plant life:

1 Nitrogen greatly stimulates utilization process and rapid growth.

2 Potassium is important in sugar formation and movement.

3 Potassium plays a role in protein formation.

Nitrogen, the most spectacular nutrient for growth, stimulates the utilization of sugars formed during photosynthesis and builds protein compounds —a necessity for top yields.

Many workers have shown that nitrogen results in lower sugar reserves through continued use for growth. With low potassium, the utilization of sugars can be at the expense of stored and reserve sugar for other uses. The result can be (1) *rank growth,* (2) *the development of non-essential protein compounds,* (3) *limited starch for grain development,* and (4) *weakened stalks and roots.*

The dual role of potassium—*aiding sugar formation and movement* **AND** protein formation—makes it difficult to conclude exactly what role it plays under any given condition.

But research has shown this: when balanced with high nitrogen, potassium regulates compounds formed and helps prevent the following hidden hunger problems:

1 TO PREVENT LODGING AND BROKEN STALKS. Adequate potassium helps balance the use of sugars for protein development and growth with the formation of cellulose, necessary for cell wall strength. Recent work on Wisconsin corn shows the necessity of N-K balance to prevent lodging. Lodging in small grain has long been associated with high nitrogen.

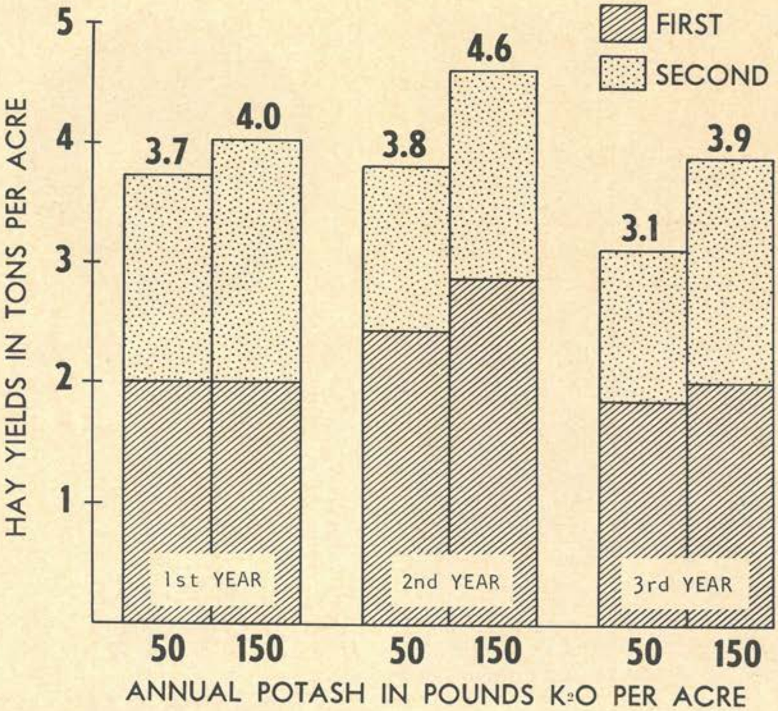
2 TO IMPROVE WINTER PROTECTION. Turf workers and forage specialists have noted greater winterkill of grasses with high nitrogen and low potassium. Grasses utilize sugar reserves for survival during winter dormancy. With high N-low K, growth is stimulated at the expense of these reserves. Balanced potassium increases the percent sugar in the tissue, thus improving winter protection. In addition, the role of potassium in sugar movement probably is a factor by aiding transfer to stems and roots from the center of formation in the leaves. Trees, shrubs, legumes, and other perennials are also protected during the winter months by an N-K balance.

3 TO LESSEN DISEASE INCIDENCE. Research work has shown that high N-low K plants have a higher incidence of disease. Balanced K strengthens cell walls and provides more food reserves to lessen any mismanagement or harmful external effects. It is believed that weakened plant tissue is more susceptible to entry by disease organisms.

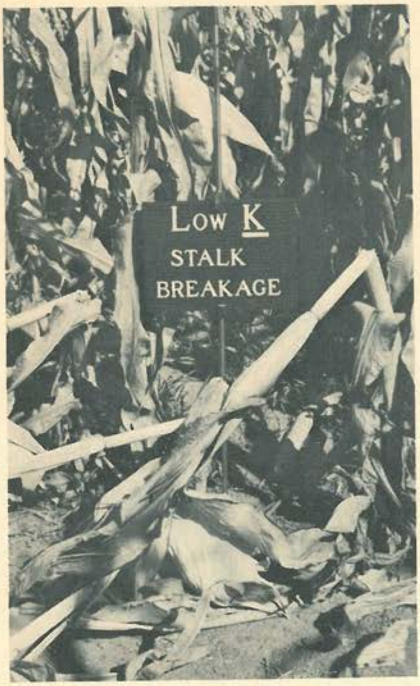
4 TO PREVENT UNFILLED EARS AND HEADS—LOW IN QUALITY. With limited nitrogen at the time of grain development, corn ears and small grain heads are underdeveloped. The entire plant machinery is slowed, thus preventing sufficient food for both stalk and grain development. In addition, the grain would be low in protein. High N and limited K results in unfilled, chaffy ears. Sugars from photosynthesis would continue to be rapidly used for growth and protein development. K is needed for normal starch development and sugar transfer to the grain.

We could cite many other examples of hidden hunger—each one a problem to the top yield farmer. Diagnosis is not easy. The answer lies in wise fertilizer practices to promote efficient, continued operation of the plant machinery throughout the year.

THE END



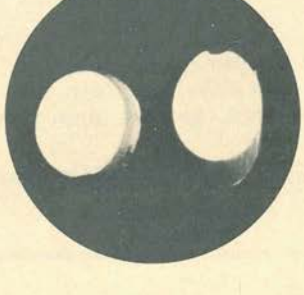
CONTINUED HIGH PRODUCTION FROM NITROGEN in the second and third years increased the grass's demand for potash, until 150 lbs. potash per acre boosted hay production nearly a ton per acre. **From the Cecil Brown tests in Maine.**

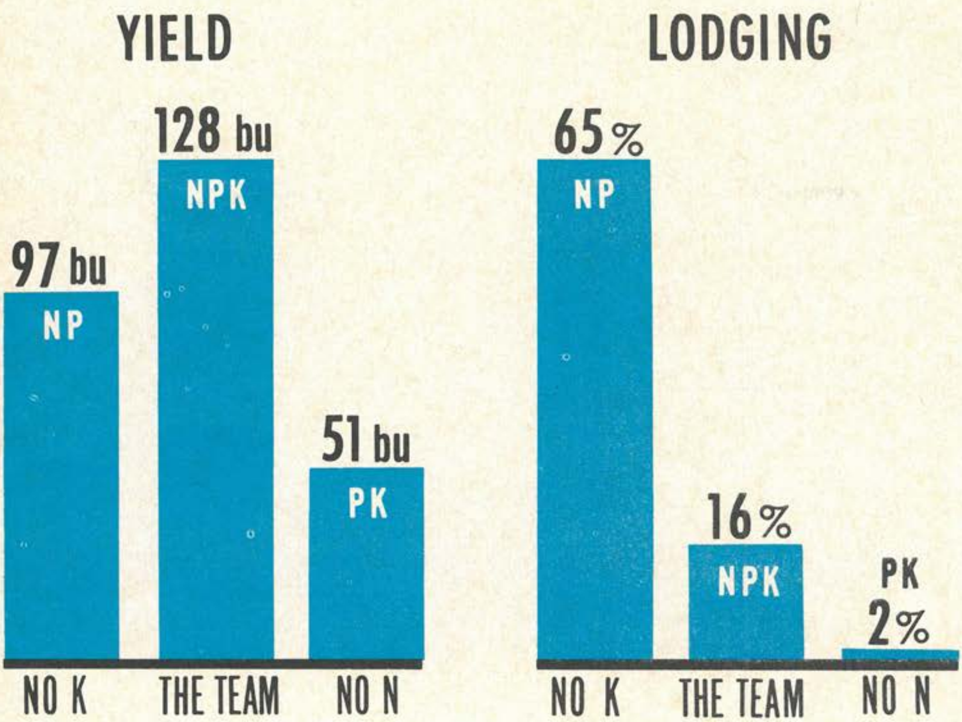


STALK CROSS SECTION

N-K MEANS PROFIT CORN!

STALK CROSS SECTION





FROM HIGH YIELDS AND LITTLE LODGING

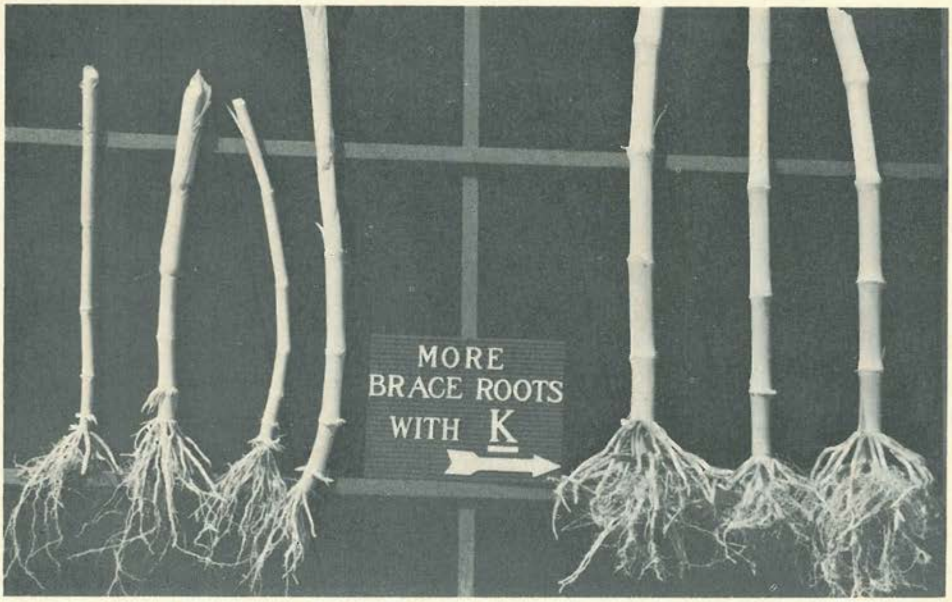
BY PAUL J. STANGEL, UNIVERSITY OF MINNESOTA

Successful corn producers know they must find ways to reduce production costs and get top profits per acre.

That is why they employ the N-K team to secure economic yields of corn grain and silage. They know corn responds well to fertilizer nitrogen in most cases, either through increased dry matter yield, protein content, or both. They also know that failure to team nitrogen with other nutrients, especially potassium, can lead to problems.

Inadequate potassium levels can lead to inefficient nitrogen use, lower yields, and higher picking losses. Failure also to team nitrogen with adequate phosphorus (as well as potassium) can delay maturity of corn by as much as two weeks—a dangerous practice for growers located on the northern edge of the Corn Belt and other areas where frost is a hazard.

Nitrogen and potassium team up to raise carotene content of corn silage and reduce gas production and dry matter losses during the fermentation process. In short, successful corn producers throughout the country know



POOR BRACE ROOT FORMATION UNDER LOW K is one of the main causes of root lodging. Here 160 lbs. K_2O were applied on right. Note vigorous brace roots and healthy stalks. Corn received 160 lbs. N and 160 lbs. P_2O_5 per acre for 5 years. K soil test = medium. Waupun silt loam—University of Wisconsin.

that signing up the N-K team in the spring means greater yields of corn and more profit in the fall.

N + K = HIGHER YIELDS AND EFFICIENT NITROGEN USE

Nitrogen fertilizers generally cause the greatest proportion of yield increase in corn grain and silage. But the most efficient results come when nitrogen is properly teamed with the other essential nutrients, especially potassium.

For example, on a Wisconsin prairie soil, nitrogen applied at adequate phosphorus levels increased corn grain yields by 51 bushels per acre. See Table 1. Potassium applied under the same conditions caused only 5-bushel increases—but yields jumped 83 bushels when *nitrogen was teamed with adequate amounts of potassium and phosphorus.*

These yield differences were predictable as early as 8 weeks after planting, because the corn plant must maintain relatively large amounts of nitrate nitrogen during early and mid-growth stages to insure top yields. If this "reserve pool" of nitrogen is drastically reduced before most growth has been completed, yields can drop sharply. See Table 1.

1 Note the big differences in nitrate nitrogen level in the corn plants sampled 47 and again 84 days after planting.

2 Note how plants receiving no fertilizer nitrogen showed relatively low nitrate nitrogen levels during early growth stages and barely detectable levels by mid-season.

Table 1. Nitrogen and potassium fertilizers influence yield and nitrogen content of corn plants (Stangel, Murdock 1960).

Treatment N	P	K	Whole Plant 47 days	82 days	Early dent		Corn Grain maturity	Yield
lbs/A			ppm NO_3-N	ppm NO_3-N	% N	% K	% N	bu/A
0	**70**	**0**	1417	Trace	0.95	0.94	1.18	**45.8**
0	**70**	**132**	784	Trace	0.94	1.62	1.28	**50.9**
160	**70**	**0**	6650	2050	1.78	0.66	1.58	**96.7**
160	**70**	**132**	7119	2538	1.75	1.79	1.55	**128.3**

3 Note how potassium added without adequate nitrogen had no effect on nitrogen reserve.

4 Note how 160 lbs. of nitrogen substantially increased the nitrogen pool of the plant—and when accompanied by adequate potassium additions, this pool increased even more.

So, it seems that nitrogen teamed with potassium causes the most efficient use of either nutrient.

N + K = EARLY MATURITY AND IMPROVED STANDABILITY OF CORN

Early frost is a constant hazard to corn producers in many areas. Combined with lodged corn during a cold wet fall, it can spell the difference between financial success and disaster.

Wisconsin work has shown that a severe nitrogen or potassium shortage can delay the appearance of silks (a measure of maturity) by as much as 14 days. See Table 2. The problem is accentuated by large amounts of one

Table 2. Nitrogen and potassium fertilization influences maturity, stalk lodging, and brace root development of corn (Stangel, Liebhardt 1960, 1962).

Treatment N	P	K	Days to 80% silk	Moisture content of grain October 1	**Plants lodged October 1**	Surface Area Covered By Brace roots October 1	K in Lower ⅓ of Plant
lbs/A			Days	%	%	Sq./in	%K
0	**0**	**0**	84	47.4	**10**	5	.20
0	**70**	**0**	91	50.2	**2**	—*	—*
0	**70**	**132**	84	44.9	**2**	—*	—*
160	**70**	**0**	80	50.3	**65**	10	0.30
160	**70**	**132**	77	43.9	**16**	46	1.90

* Not measured but assumed to be about the same as for the crop receiving the 0-0-0 treatment.

nutrient—nitrogen, potassium or particularly phosphorus—applied in the absence of adequate levels of the other nutrients. Yet, in all but the most extreme cases, this maturity delay is usually 7 days or less. But in areas where frost is an ever-present threat (on the northern fringe of the Corn Belt) such delay can spell the difference between low moisture storable corn and corn that must be artificially dried before it can be stored.

A balanced fertilization program can insure your crop maturing at the earliest possible date—whether maturity is measured by appearance of silks or by moisture content of corn grain at harvest (Table 2).

Low moisture corn can save the grower the expense of artificial drying before storage.

Badly lodged corn means high picking losses. See Figure 1. This can be avoided with generous additions of potassium fertilizers. Failure to team nitrogen fertilization with adequate amounts of potassium can lead to disaster. See Table 2.

Corn lodging increased to 65 percent when high amounts of nitrogen and phosphorus were applied to a Wisconsin soil deficient in available potassium. Additions of potassium to the N-P combination reduced this lodging to only 16 percent.

Part of the lodging problem came from poorly developed brace roots on the potassium deficient plants. This brace root development was not affected by fertilizer additions of either nitrogen or phosphorus. The surface area covered by brace roots increased five- to tenfold when fertilizer potassium was teamed with adequate nitrogen and phosphorus. See Figure 2.

N + K = INCREASED PROTEIN, REDUCED FERMENTATION LOSSES

Teaming nitrogen with potassium and adequate phosphorus *increases* dry matter, protein, and carotene content of the plant and *reduces* gas production and dry matter loss during silage fermentation. (Table 3.)

Wisconsin work now shows that nitrogen fertilization can increase the protein content in corn grain by as much as 35 percent and in corn silage by nearly 90 percent.

Potassium does not greatly affect the protein content of either the corn

Table 3. Nitrogen and potassium fertilizers influence protein and carotene content of corn, as well as losses during fermentation of silage (Stangel, Baumgardt, 1964).

Treatment			Plant Composition		Protein	Gas	Fermentation
N	P	K	Protein	Carotene	Production	Production	Losses
lbs/A			%	mgm/lb D.M.	lbs/acre	Relative	% D.M.
0	70	0	5.9	*	253	High	7.0
0	70	132	5.9	8.6	304	High	7.3
160	70	0	11.1	21.0	840	High	6.8
160	**70**	**132**	**10.9**	**57.4**	**910**	**Low**	**2.1**

* Not measured but assumed to be similar to values for the crop receiving the 0-70-132 treatment.

grain or silage *but does increase protein production* through increased yields from the added potassium.

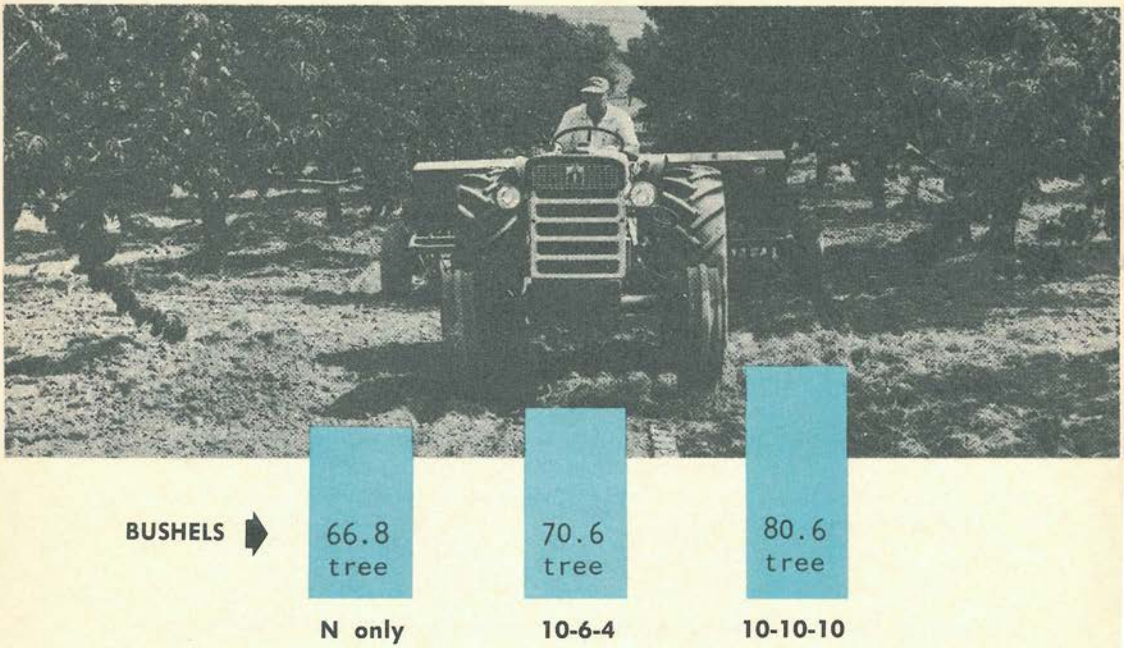
For example, the crop grown on soil deficient in nitrogen and potassium but with adequate phosphorus produced only 253 lbs. of protein by mid-August. Additional potassium fertilizer increased the protein yield only slightly. Additional nitrogen provided 840 lbs. protein—a 350% increase. Potassium supplied along with the nitrogen gave an additional 70 lbs. protein.

Carotene, a precursor of Vitamin A, *increased with the addition of nitrogen or potassium* (Table 3). This shift in quality may be every bit as important to the herdsman as the increase in protein content.

Fertility can also affect the amount of gas production and fermentation losses during silage formation. Preliminary lab reports reveal relatively large amounts of gas produced during silage fermentation *when the crop was deficient in either nitrogen, potassium or phosphorus* (Table 3). Such conditions may cause dry matter losses to run as high as 7-8% when the crop is ensiled. But when adequate nitrogen, phosphorus and potassium are all available, gas production levels and dry matter losses are moderate.

Thus, it appears nitrogen and potassium team up in many ways to make the corn producer money.

THE END



Where The **PROFIT** Is In The **BALANCE**

Many fruit growers have the idea that the only fertilizer required for bearing fruit trees is nitrogen. It is rationalized that trees with their extensive and deep root systems are able to extract adequate amounts of the mineral nutrients from most soils. Short term research is often quoted to support this fallacy.

MODERN CONCEPT INCLUDES P & K

The modern concept regarding the need of fruit trees for phosphorus and potassium can best be illustrated by the long term nutrition studies now underway at Pennsylvania State University. There, Dr. C. Marshall Ritter and co-workers have discovered that phosphorus and potassium are important factors in determining yield of fruit, but more importantly, quality of fruit. For the first several years of their study on Elberta peach trees, results were about the same as everyone else had obtained . . . nitrogen was the only element giving significant response in yield.

But then some things began to happen. At nitrogen rates high enough to maintain high yields, moderate to high rates of phosphorus and potas-

The bars above represent cumulative yield average—17 years, 4 apple varieties, University of Delaware (ferilizer applied to give .16 lb. N per year of tree age).

sium began to have an effect on yield. High phosphorus also began to have an effect on yield. High phosphorus also began to show a *definite positive effect on fruit quality*. After nine years of continuous fertilization, best yields and quality are now being obtained by individual tree applications of 1/6 pound nitrogen, 2 pounds P_2O_5 and 1/3 pound K_2O. A cover crop fertilization program consisting of 250 pounds of 5-10-10 at seeding has also been applied each year. Thus, the total fertilization received by the trees producing the best results is approximately 25 pounds of N, 190 pounds *P_2O_5 and 70 pounds K_2O per acre.*

High nitrogen rates with lower amounts of P and K actually produced higher yields but these trees produced excessively large fruit, many with split pits, which ripened too slowly and never attained a desirable color. These trees also set hardly any fruit in the upper third of the tree. Trees receiving high nitrogen and potash with low phosphate, comparable to the presently recommended peach fertilization practice in Pennsylvania, also produced acceptable yields, but when submitted to an expert taste panel were found to be bitter, or astringent, and generally of poor eating quality.

Dr. V. J. Fischer in long term fertility trials at the University of Delaware has also obtained significant yield response from phosphorus and potassium as shown in the accompanying data.

LONG-RANGE OUTLOOK PAYS

Through leaf analysis and other advanced techniques, the need for potassium and several of the secondary and micronutrients is being better understood. But phosphorus is still generally being ignored or neglected in many of the fruit growing states. Why is it that research in one state shows outstanding response to phosphate fertilization and its neighbor with equally phosphorus deficient soils believes that for all practical purposes, this nutrient need not be considered? Is this because research has been inadequate or terminated too quickly?

We do not have these answers, but would like to point out that a long period of time, probably six to eight years or more, intervenes between the time a deficiency begins to exist in the soil and when it may show up on a mature tree. We believe that present evidence would indicate that fruit growers would do well to reconsider the importance of phosphate in their own program in light of this possibility.

H. H. Nau—In Cyanagrams

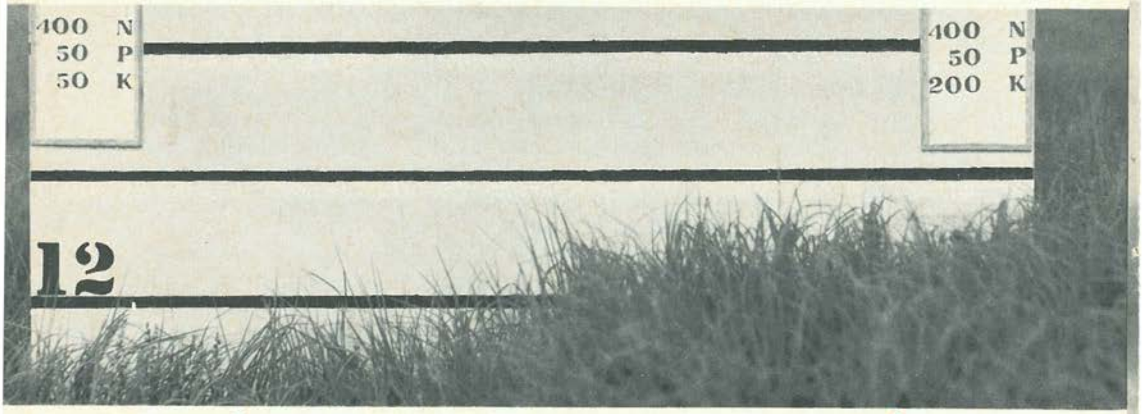
A MATTER OF OPINION

Ideas are like children—your own are very wonderful.

My elderly uncle, who could walk for miles on his own acres of woodlands and meadows back home, was finally persuaded to visit his daughter who lived in an apartment near Chicago's downtown loop.

After he had been visiting a few days and had looked things over a bit, his daughter asked him what he thought of Chicago. "Well," said Uncle Bill reflectively, "the thing I don't like about it is that the minute you step out the door you're away from home."

Where did parents learn all the things they tell their children not to do?



8-1 (N-K) RATIO   2-1 (N-K) RATIO

N-K Ratio

Important Factor In Coastal Bermudagrass Forage Production

BY WILLIAM E. ADAMS, USDA
SOUTHERN PIEDMONT CONSERVATION RESEARCH CENTER
WATKINSVILLE, GEORGIA

Coastal Bermudagrass is one of the most important summer grasses adapted to the Southeastern United States.

Georgia alone has more than 700,000 acres. Though it was originally thought adapted to the sandy soils of the Coastal Plain, interest in the Piedmont Region is growing rapidly, with 185,000 acres already planted in the Georgia Piedmont.

Coastal will produce good forage yields on practically all the well-drained soils of Southeastern United States. Optimum yields can be produced at a soil pH of from 5.0 to 7.2.

The experiment reported here was initiated to answer some practical management problems associated with Coastal Bermudagrass forage production. Coastal Bermudagrass was established on Cecil sandy loam soil, limed to pH 6.5. One year later, N and K variables were imposed on the experimental area. Phosphorus was applied at the rate of 87 lbs./acre of P

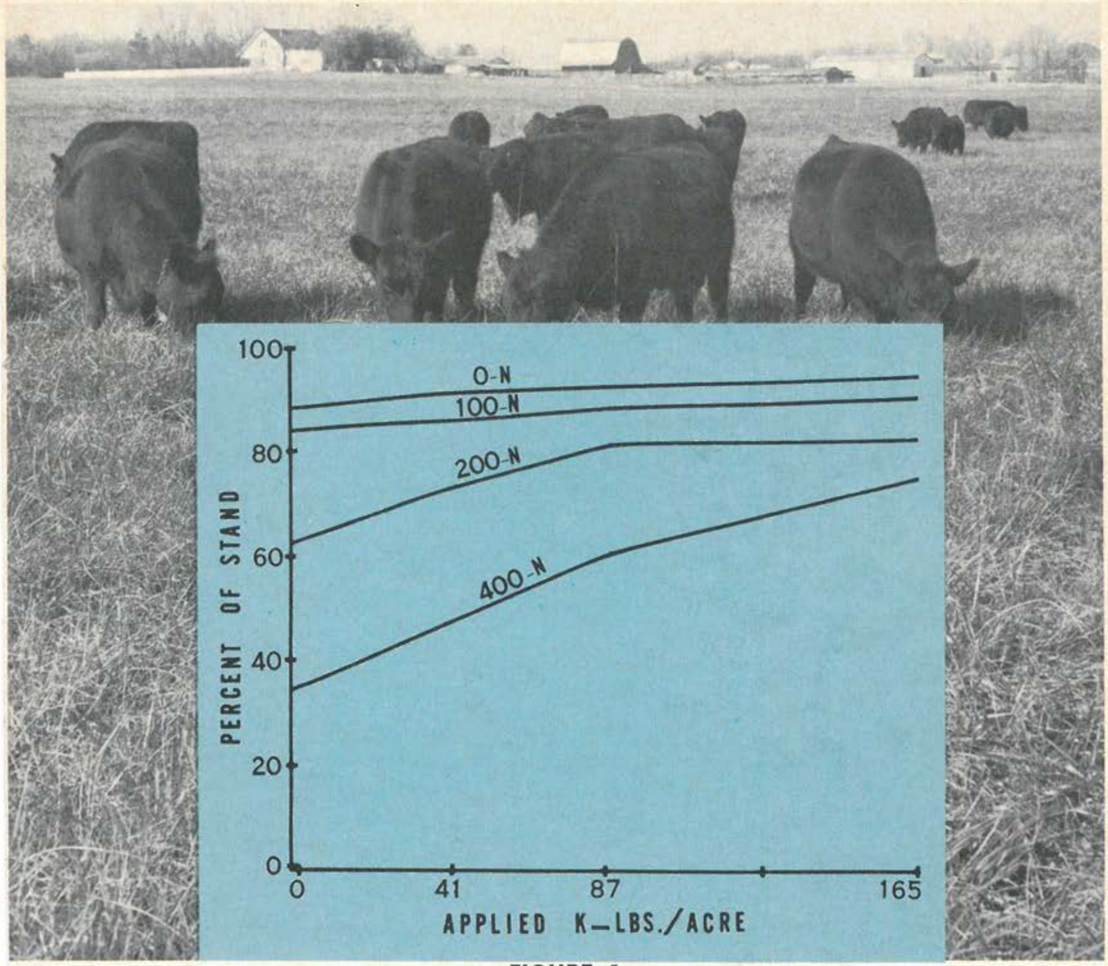


FIGURE 1

TEAM POTASSIUM WITH NITROGEN to help prevent winterkill—as shown by these four levels of applied N and K on Coastal Bermudagrass stand, 1958. Even better stands might have been secured with higher K rates especially at the higher N rates.

(200 lbs. P_2O_5). Nitrogen (in the form of ammonium nitrate) was applied in three equal applications: (1) April 1, (2) after the first grass harvest, (3) after the second grass harvest. The P and K were applied April 1.

NUTRITION OF COASTAL

Table 1 shows how the average forage yields of Coastal Bermudagrass varied widely with the fertility treatments—from 2.24 tons/acre for the 0-0 (N-K) treatment to 7.32 tons/acre for the 400-165 (N-K) or 400-200 (N-K_2O) treatment. Obviously nitrogen is more critically limiting than potassium for Coastal Bermudagrass forage production. Forage production was increased about twofold by adding 100 lbs./acre of N, but was not increased by K without N.

Table 2 shows the increases in Coastal Bermudagrass forage per pound

TABLE 1. INFLUENCE OF N-K FERTILIZER RATIO ON COASTAL BERMUDAGRASS FORAGE PRODUCTION 1955-57.

Nitrogen*	Potassium, Lbs./Acre			
	0	41-K ($50-K_2O$)	83-K ($100-K_2O$)	165-K ($200-K_2O$)
Lbs./Acre	Forage, Tons/Acre*			
0	2.24	2.47	2.94	2.48
100	4.26	4.71	4.83	4.85
200	5.17	5.50	5.85	6.44
400	**5.66**	**6.25**	**7.11**	**7.32**

* At 87 lbs./acre P.

of applied N—calculated from the data in Table 1. The greatest increase—47 lbs. forage per pound of N applied per acre—occurred with 100 lbs. of N and 165 lbs. of K.

Table 3 shows the increase in forage production per pound of applied K. An increase of 29 lbs. of forage per pound of K applied per acre occurred at the 400-41 (N-K) rate. Even at the highest K rate of 165 lbs., 20 lbs. of forage were produced per pound of K with 400 lbs./acre of N—a high return for the relatively low cost of K.

Potassium deficiency symptoms were observed on all plots with high N, low K levels.

The above discussion dealt with N and K as variables, while P was applied at a constant rate of 87 lbs./acre. Coastal Bermudagrass did respond to P, but detailed data are not included here. Forage production was progressively and significantly (5% level) increased by P applications of 22, 44, and 87 pounds per acre at N rates of 0, 100, 200, and 400 lbs./acre.

N-K BALANCE

While this study has shown the effect of various N-K ratios on Coastal yield, other investigators have shown the importance of N and K balance in the forage diet animals consume. For the animal to get an adequate supply of K, the forage plant must be adequately supplied.

. . . TO HELP PREVENT WINTERKILL

The importance of N-K balance in preventing winterkilling of Coastal Bermudagrass was noted in the spring of 1958 in a soil fertility experiment. Detailed studies determined the extent of cold injury and the relation between winter damage and past treatment:

1 In the absence of N fertilization, good stands were maintained regardless of potash fertilization level.

2 With increasing amounts of N, the Coastal Bermudagrass stands became progressively poorer, especially on plots that received no potash. Potash fertilizer was highly effective in counteracting the injurious effects of high N.

TABLE 2. INCREASE IN COASTAL BERMUDAGRASS FORAGE PRODUCTION PER POUND OF APPLIED NITROGEN

Nitrogen	Potassium (K), Lbs./Acre			
	0	41	83	165
Lbs./Acre	Increase in Forage, Lbs./Lb. N/Acre			
100	**40**	**45**	**38**	**47**
200	29	30	29	40
400	17	19	21	24

3 On plots receiving 165 lbs. K per acre per year, Coastal Bermudagrass stands averaged 75 percent, even with 400 lbs. N per acre each year.

4 The slope of the curves in Figure 1 suggests that even better stands might have been obtained with higher K rates, especially at the higher N rates.

. . . TO PREVENT SOIL K DEPLETION

Soil test determinations for dilute acid-soluble (.O5HC1 and .025 H_2SO_4) K show that high N fertilization was associated with the depletion of soil K (Table 4).

In October 1954, the top 6 inches of soil contained about 95 lbs./acre of K. Three years later the O-N plots still showed 92 lbs./acre of K, compared with only 30 lbs./acre for the 400-N treatment. This marked depletion of available soil K under heavy N fertilization was associated with higher removal of K in the Coastal Bermudagrass forage.

On the plots receiving 165 lbs. of K per year, K removal in the forage averaged 54, 161, 220 and 268 lbs./acre/year, for the 0-, 100-, 200-, and 400-N levels, respectively. *Therefore, K removal was greater than the rate of application for the 200- and 400-N levels.*

. . . TO HELP REDUCE LEAF SPOT

The N-K balance in the plant has also been found related to leaf spot

TABLE 3. INCREASE IN COASTAL BERMUDAGRASS FORAGE PRODUCTION PER POUND OF APPLIED POTASSIUM

Nitrogen	Potassium (K), Lbs./Acre		
	41	83	165
Lbs./Acre	Increase in Forage, Lbs./Lb. K/Acre		
0	11	17	3
100	22	14	7
200	16	16	15
400	**29**	**35**	**20**

TABLE 4. EFFECT OF N RATES ON ACID-SOLUBLE K IN 1954 AND 1957

Nitrogen	Potassium* 1954	1957
Lbs./Acre	K, Lbs./Acre	
0	**95****	**92**
100	87	59
200	87	40
400	**91**	**30**

* At the 165-lb./acre K rate of application. K was extracted with a dilute acid solution of .05 HC1 and .025 H_2SO_4, giving a total normality of .075.

** Each value is a mean of 48 entries.

on Coastal Bermudagrass. Alabama Agricultural Experiment Station tests indicate that Coastal Bermudagrass fertilized with a 2-1 (N-K) ratio had less leaf spot infestation than forage receiving higher N-K ratios.

In summary, good management encourages proper N-K balance in fertilizing Coastal Bermudagrass. The reasons seem clear:

1. To help get top level yields.
2. To help prevent winterkill of the grass.
3. To help reduce leaf spot infestation.

THE END

POTASH HELPS SOYBEANS

. . . in Kansas

Inadequate amounts of potash in southeast Kansas soils can limit soybean yields and profits, says Verlin Peterson, superintendent of Kansas State University's Columbus Experiment Field.

Although numerous fields in southeast Kansas show potash hunger signs, many farmers fail to recognize the symptoms and refer to potash-starved soybean plants as blight-ridden, Peterson reports.

Farmers often fail to consider that a 40-bushel soybean crop takes up 80 pounds of potassium per acre which must be replenished to provide sufficient nutrients for succeeding crops.

Special consideration should be given to potash usage on early plantings, Peterson advises, and on fields where soybeans are planted 2 or 3 years in succession. During the past 5 years of soybean rotation experiments at the Columbus Field, adequate use of potash has produced average yield increases of 5 bushels per acre.

Potash applications are not necessarily reflected by increased plant height, since yield responses in tests were attributed primarily to better pod and seed development. Many of the wrinkled, offcolor beans can be eliminated by proper potash use.

Kansas Farmer

A Few Whinnies

Doctor (explaining his bill): "Don't forget, I made eleven visits to Johnny when he had the measles."

Johnny's mother: "And don't you forget, Johnny made you a lot of money by giving the measles to the whole fourth grade!"

A husband of ten years was consulting a marriage counsellor.

"When I was first married, I was very happy. I'd come from a hard day at the shop; my little dog would race around barking and my wife would bring me my slippers. Now, after all these years, everything's changed. When I come home, my dog brings me my slippers, and my wife barks at me!"

"I don't know what you're complaining about," said the counsellor. "You're still getting the same service."

After ten years with the company, the model employee—never late, never absent, never a shirker—walked into the office one morning scratched, bruised and bloodied, his clothes ripped and torn.

"How come you're late?" asked the boss.

"I was crossing the street and got run over by a bus and dragged 40 feet," replied the tattered employee.

"That took an hour and a half?"

The shoe salesman was stunned when the shapely gal he had been waiting on slapped his face and tore out of the store.

"What the blazes happened," roared the boss.

"I don't know," replied the puzzled clerk. "All I said to her was 'these shoes will make street-walking a pleasure'."

The drunk staggered into the bar and shouted: "Happy New Year everybody."

The guy closest to him said: "Aw, shut up. It's the middle of August."

"August," the drunk mumbled, "oh my gosh, my wife will kill me. I've never been this late before."

"You say this woman shot her husband with a pistol and at close range?" asked the judge of the eyewitness to the tragedy.

"Yes, sir."

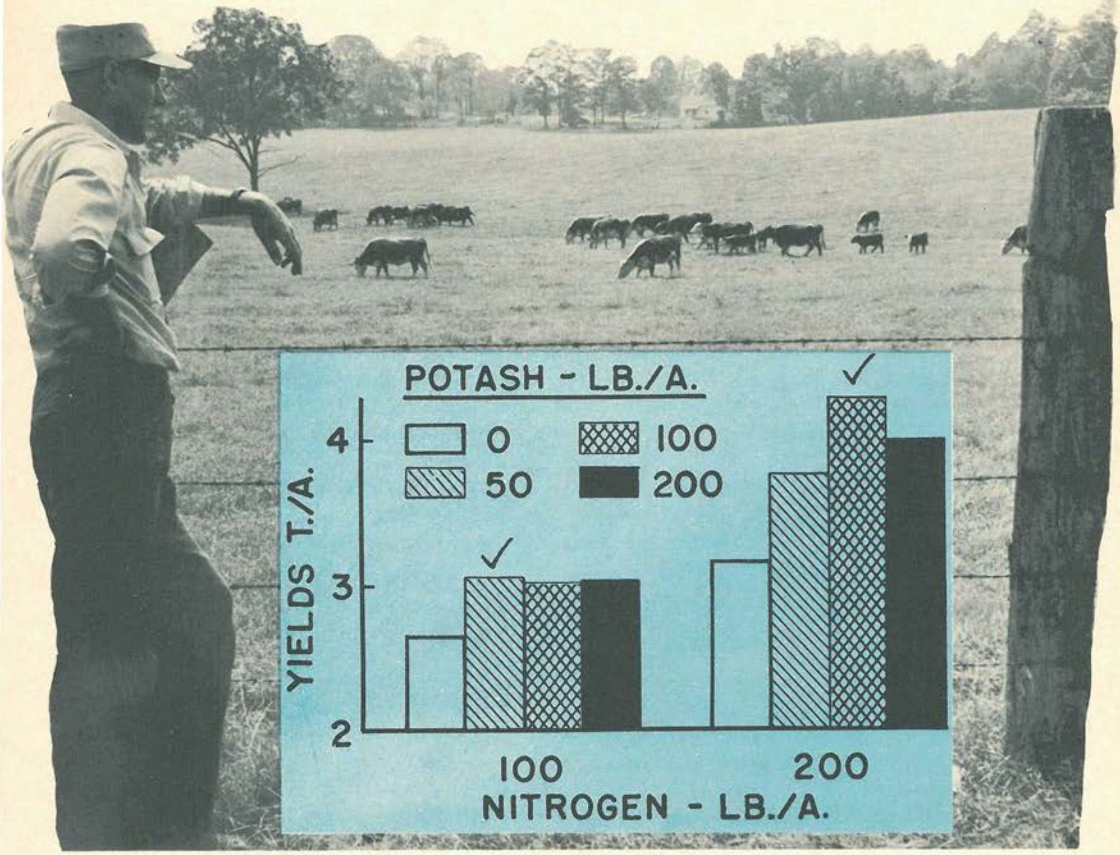
"Were there any powder marks on his body?"

"That's why she shot him, judge."

Two men were pacing the waiting room near the maternity ward.

"What tough luck," one man said. "This had to happen during my vacation."

"You think you got troubles," the other man said. "I'm on my honeymoon."



N-K PARTNERS In Forage Grass PRODUCTION

"It takes two to tango." This applies not only to people, but also to the fertilization of forage grasses. When nitrogen and potassium are in step with each other and with other plant nutrients, high yielding, high quality grass forage is possible.

Bluegrass, bromegrass, orchardgrass, and timothy are important hay and pasture crops in the north-central and northeastern regions of the United States. Midland bermudagrass is a warm season grass which shows forage potential in some parts of these and other regions.

The smooth-working relationships of nitrogen and potassium in these

FIGURE 2.

WHEN K CONTENT of orchardgrass fell below 1.6%, asparagine content became abnormally high (Griffith, et al., 1964).

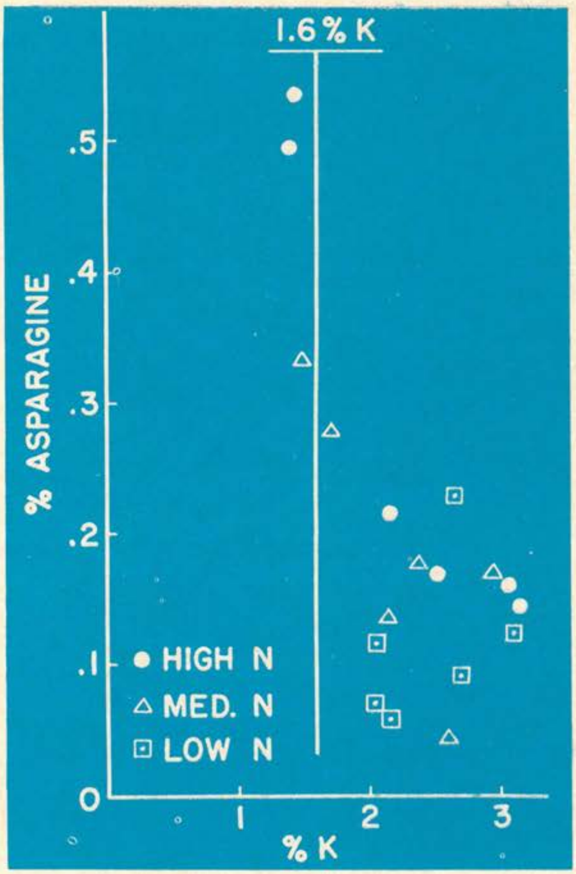


FIGURE 1.

ORCHARDGRASS responded best to N applied in a 2 to 1 ratio with potash.

BY CONRAD B. KRESGE UNIVERSITY OF MARYLAND

grasses have been revealed by (1) high yields and protein contents, (2) excellent nutrient recovery, (3) disease resistance, and (4) winter hardiness.

HIGH YIELDS FROM N-K PARTNERSHIP

Nitrogen usually increases yields. But the efficiency of the nitrogen depends, for one thing, on a proper balance with potassium. Figure 1 demonstrates this point. Several rates of nitrogen and potassium were applied to orchardgrass in all possible combinations. Dry matter yields were increased by nitrogen up through the 200-pound per acre rate. At each rate of nitrogen, this nutrient was able to work most efficiently *when it was applied in a 2 to 1 ratio with potash.*

TABLE 1. A 2 TO 1 RATIO OF APPLIED N TO K_2O RESULTED IN EXCELLENT NUTRIENT RECOVERY BY ORCHARDGRASS FORAGE

	Nutrients applied (lb./A.)			Nutrients Recovered—%		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	100	100	0	69	62	—
⟶	**100**	**100**	**50**	**81**	**62**	**156**
	100	100	100	63	61	105
	100	100	200	68	55	81
	200	100	0	61	52	—
	200	100	50	73	60	202
⟶	**200**	**100**	**100**	**84**	**71**	**212**
	200	100	200	67	60	133

HIGH PROTEIN CONTENT FROM N-K PARTNERSHIP

Nitrogen also increases the nitrogen content of grass forage. To benefit animals, most of the nitrogen must be in the protein form. When nitrogen and potassium are out of balance, some of the nitrogen in the plant may be nonprotein. What happens then? Certain levels of amino acids, amides, and other forms of nonprotein nitrogen can (1) depress animal absorption of calcium and magnesium, (2) raise the acidity in the rumen fluid to an undesirable level, (3) cause inefficient use of energy by the animal, and (4) create ammonia in excess of the liver's filtering capacity.

Orchardgrass investigations in Indiana showed that *asparagine,* an amide, increased with increased rates of nitrogen when potassium content was forced below 1.6%. See figure 2. Asparagine did not accumulate when the potassium level was adequate. It is thought that potassium deficiency hampers the combination of amino acids into proteins and allows existing proteins to break down into nonprotein nitrogen.

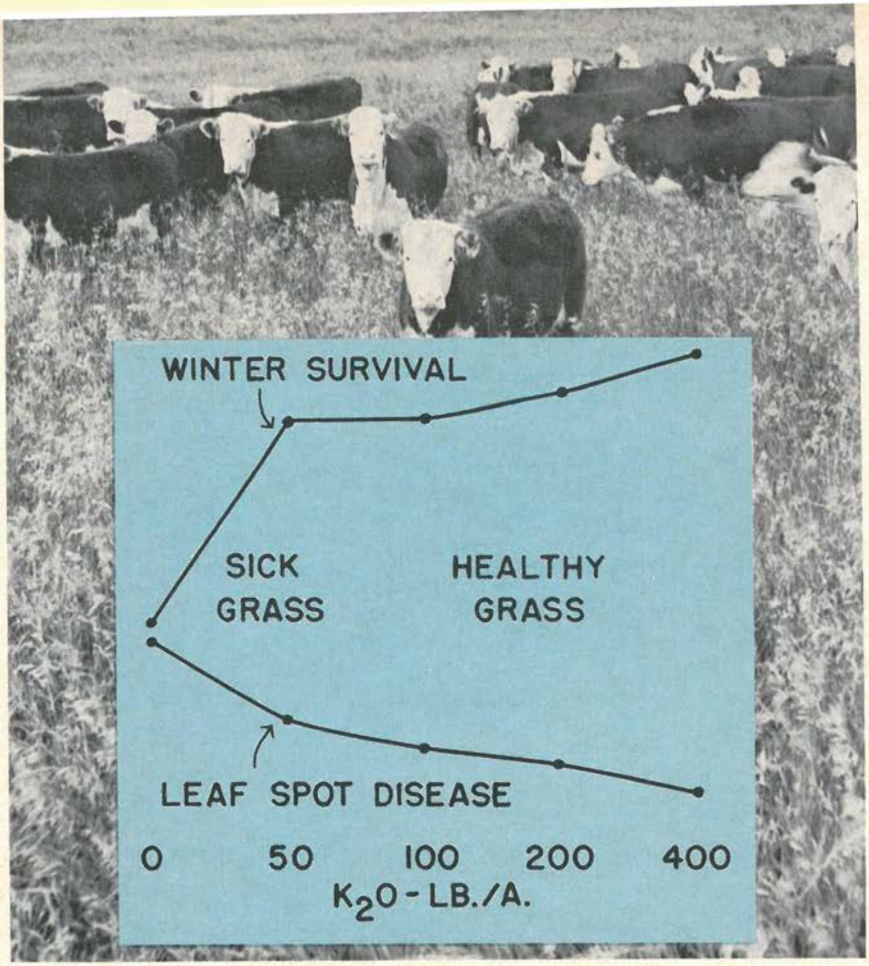
EXCELLENT NUTRIENT RECOVERY FROM N-K TEAM

Another measure of efficiency of nitrogen and potassium fertilization

TABLE 2. HIGH YIELDING GRASS REMOVED ALMOST AS MUCH POTASH AS WAS APPLIED (PARSONS ET AL., 1953).

Grass	Lbs. K_2O Added	Lbs. K_2O Removed	Hay Yield* T/A
Orchard	650	**565**	11.06
Brome	550	**518**	11.79
Timothy	450	**354**	12.15

* Total for 3 years.



AS MORE POTASH was applied to bermudagrass, disease decreased and winter survival increased. **FIGURE 3.**

is nutrient recovery. (When referring to nutrient recovery, it is recognized that all of a particular element recovered in harvested forage does not come from the applied fertilizer—some is probably provided by the inherent soil fertility).

Table 1 shows nutrient recovery facts from the Maryland orchardgrass experiment, discussed earlier. Recovery of nitrogen, phosphorus, and potassium was highest at each nitrogen rate when the ratio of applied nitrogen to potassium was 2 to 1.

The amount of potassium recovered often exceeded that applied. This means that the soil potassium reserve was being "mined" by the grass, a high potassium consumer. Table 2 shows how difficult it was to increase the potassium reserve in some Massachusetts soils when producing large yields of forage grasses. Since most high yielding grasses will apparently take up most of the soil potassium available, it is important to apply only the amount needed for proper balance.

Not only is the total recovery of certain nutrients higher in forage with a *balanced nitrogen and potassum partnership* but their concentrations in

TABLE 3. N, P, AND K CONTENTS OF BLUEGRASS WERE HIGHEST WHEN NUTRIENTS WERE BALANCED (WALKER & PESEK, 1963).

Nutrients applied—(lb./A.)			Forage content—%		
N	P_2O_5	K_2O	N	P	K
40	30	20	2.30	.213	1.44
40	30	60	2.26	.221	1.54
40	90	20	2.28	.256	1.49
40	**90**	**60**	**2.34**	**.268**	**1.55**
120	30	20	2.82	.208	1.69
120	30	60	2.84	.217	1.74
120	90	20	2.78	.255	1.68
120	**90**	**60**	**3.04**	**.271**	**1.82**

the forage can also be higher. Table 3 shows some Iowa results with bluegrass. The nitrogen, phosphorus, and potassium contents in harvested forage were highest when the nutrients were in proper balance. For example, raising the nitrogen rate from 40 to 120 pounds increased the percent potassium. When the phosphorus rate was increased, nitrogen percent increased while potassium was in balance.

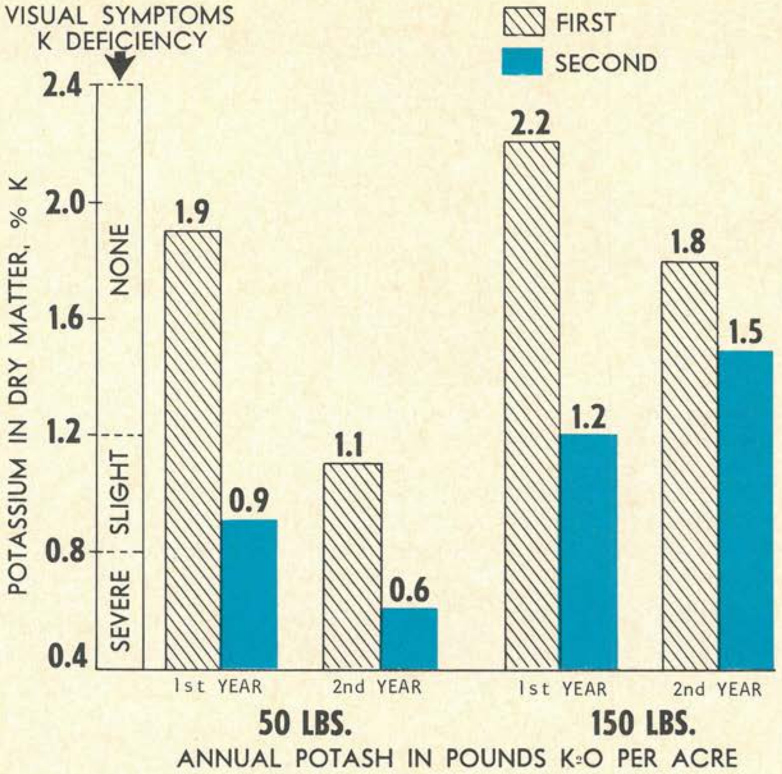
DISEASE RESISTANCE AND WINTER HARDINESS FROM N-K TEAM

A balanced nitrogen and potassium performance helps put vigor into grasses. Healthy plants can resist the ravages of disease and winter.

In a Maryland study, different amounts of nitrogen and potassium were applied in various combinations to Midland bermudagrass. Figure 3 shows how *Helminthosporium* leaf spot disease decreased as potassium rate increased. This was true at all nitrogen rates. The healthy grass was also able to survive severe winter conditions better than the potassium deficient grass.

The interrelationships of nitrogen and potassium in grass forage are complex, are only partly understood. But the evidence is clear: these two nutrients can "make beautiful music together." That music is healthy grass, producing high yielding, high quality forage.

THE END



WHEN RECEIVING ONLY 50 lbs. POTASH PER ACRE, this timothy dipped into slight and severe hunger signs after the first cutting in the first year. The crop receiving 150 lbs. potash per acre managed to stay above visual hunger signs though it dipped sharply in potash content on the second cutting of each year. **From the Cecil Brown tests in Maine.**

DID YOU KNOW . . .

SOME SOILS may contain 50,000 lbs. potassium per acre furrow slice (7 inches), but with less than 100 lbs. of it *available* to the plant.

YOUR SOIL must be able to supply large amounts of plant food during periods of rapid growth—such as the 120-bushel corn yield that took up 98 lbs. or 69% of its total potash need during the *first two months.*

ORDER BOOKLET, **POTASSIUM FOR AGRICULTURE,** PAGE 48

N-K Ratio May Influence TOMATO GRAYWALL

One of the most serious problems confronting the producers of mature-green tomatoes is a poorly understood fruit disorder most commonly called graywall in Florida. Symptoms on green or ripening fruit occur beneath the cuticle in the outer walls generally along vascular bundles, and can be seen from the outside as gray to brownish areas—shown above.

Since the discovery of graywall resistance in certain Florida tomato breeding lines (reported in *Research Report,* April 1958), several highly resistant tomato varieties have been released. Of these, Manalucie, Indian River, and Manapal are the varieties used in Florida's important and growing trellised "vine-ripe" tomato industry. However, none of the resistant varieties has been entirely acceptable to the producers of mature-green marketed fruits.

The highly productive strains of the Homestead variety are used by most growers who market tomatoes in the mature-green stage. This variety is very susceptible to graywall.

GRAYWALL-NITROGEN RELATION

Past observations have indicated a positive relationship between high nitrogen and graywall severity. Previous N, P, and K factorial experiments with tomatoes have been upset by untimely leaching rains. With the availability of black polyethylene film it is now possible to eliminate most leaching.

A relationship involving graywall was observed in a fall tomato experiment where varied nitrogen-potash ratios were included. Most treatments were applied in one application, and the plant beds were then covered with 1.5 mil black plastic film. Some of the treatments were duplicated without the plastic film, and one of these received weekly foliar applications of N, P, and K.

The fertilizer source materials were ammonium nitrate, triple superphosphate, potassium chloride, and potassium sulfate. The nitrogen-potash ratios used were 1:8, 1:4, 1:2, 1:1, 4:1 and 8:1.

The variety Homestead-24 was seeded in peat pots. The young plants were transferred to field plots immediately after the plant beds were made, the fertilizer treatments applied, and the plastic film laid.

GRAYWALL-POTASH RELATION

Examination of harvested fruits revealed that the amount of graywall

TREATMENTS, RATIOS, AND PERCENT OF TOMATOES WITH GRAYWALL

Treatment	Lbs./A			$N:K_2O$ Ratio	Percent of Fruit with Graywall*
	N	P_2O_5	K_2O		
WITH PLASTIC FILM					
1	50	200	400	1:8	11
2	100	200	400	1:4	15
3	100	200	200	1:2	19
4	100	200	100	1:1	29
5	**400**	**200**	**100**	**4:1**	**41**
6	**400**	**200**	**50**	**8:1**	**49**
7	**400**	**800**	**800**	**1:2**	**14**
WITHOUT PLASTIC FILM					
8	100	200	200	1:2	7
9	400	800	800	1:2	16
WITHOUT PLASTIC FILM AND SPRAYED WITH N, P, AND K SOLUTION					
10	100	200	200	1:2	7

* Average of 5 replications.

Duncan's New Multiple Range Test (99:1)

Treatment	10	8	1	7	2	9	3	4	5	6

varied greatly in number of fruits affected and in severity of break-down of individual fruits. The percent of fruit showing graywall was lowest in low nitrogen-high potash plots and highest in high nitrogen-low potash treatments. When the rate of fertilization was increased fourfold with a constant ratio, the percent graywall remained approximately the same.

Due to rainfall, all treatments without the plastic film were leached heavily. The difference in graywall severity of the lower rate of fertilizer with and without the plastic mulch may have been due to lower nitrogen where the mulch was not used. These plants were much lighter in color and by growth response clearly indicated a lack of nitrogen.

The foliar applications of N, P, and K did not have an effect on the percent of fruit with graywall.

The results are from one experiment under one set of environmental conditions. Further tests are in progress to determine if the relationship can be duplicated, and if the high N-low K ratio will consistently produce fruits with graywall. Conclusions would be premature until additional research is completed. The nitrogen-potash ratio of 4-8-8 formulation used by most tomato growers (1:2) was in this test as low in graywall as the 1:4 or 1:8 ratios. However, the ratio of the 15-0-14 or 10-0-10 formulas (1:1) commonly used as topdressed treatments was somewhat higher in graywall.

N. C. Hayslip & J. R. Iley—
In Sunshine State Agricultural
Research Report.

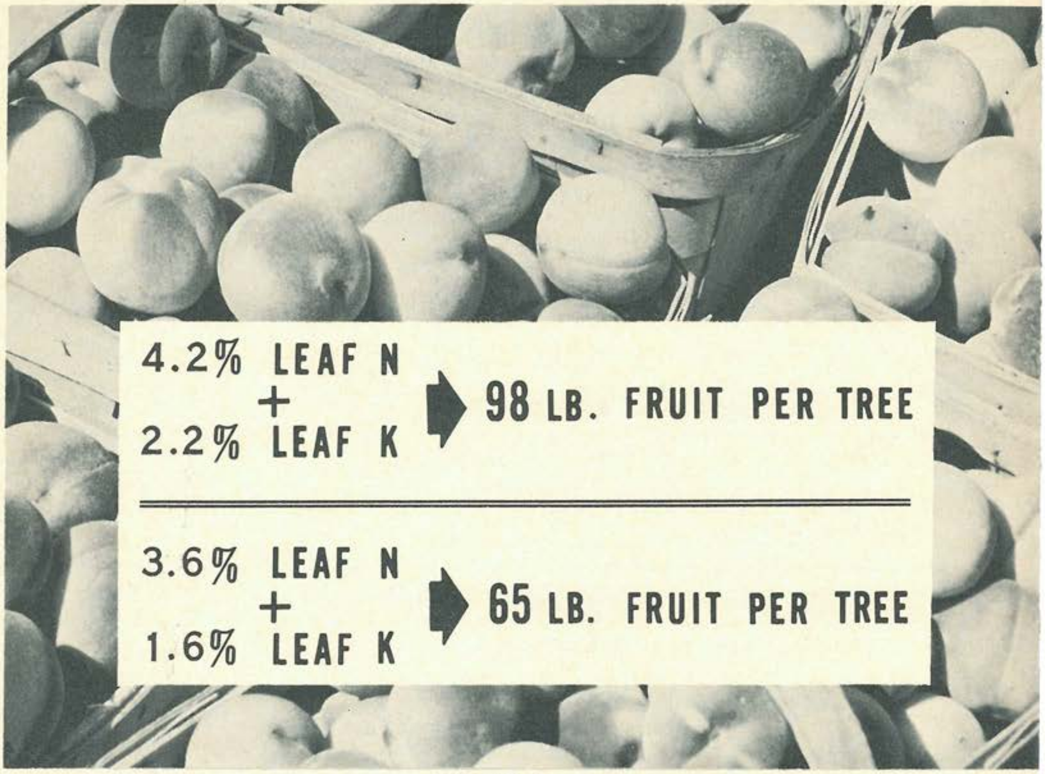


FIGURE 1

HIGH N-K PEACH TREES PRODUCE MORE . . .

33 lbs. MORE PEACHES PER TREE
1.75 MORE TONS PER ACRE
$175 MORE GROSS RETURN PER ACRE

Do peaches need nitrogen and potassium? Ontario work shows they do.

A peach fertilization experiment at Vineland once showed that 300 lbs. per acre muriate of potash applied annually increased net return $66 per acre per year over a 12-year period (1940-52). Manure applications resulted in higher levels of leaf N and K, and higher yields, than the K treatment alone.

Do peach trees respond to phosphorus? Most reports indicate not. Yet, while P alone gave no response in this experiment, the PK treatment returned a profit of $110 per acre and the yields were almost as high as where manure was also applied.

Despite the increased production from increased K supply (whether mineral or manure), no deficiency symptoms were seen in the 12-year experiment. Hidden deficiencies are expensive. Leaf K values for mid-July samples ranged from 1.29 to 2.36%.

Current research indicates the same trend. See Figure 1. Eight fertilizer and 4 management treatments were applied to young Elberta and Veteran peach trees. The 16 high-yielding and 16 low-yielding treatments were grouped. Values are for 5-year-old Veteran trees.

The 33 lbs. increase per tree (65-98 lbs.) means 1¾ tons more peaches per acre, or $175 increase in gross returns. With these young trees, potash by itself increased leaf K, but hay mulch greatly increased it and also raised leaf nitrogen and total yield.

In 1962, potash + manure almost doubled the yield of 4-year-old Veteran peach trees—*from 62 to 112 lbs. per tree!* The untreated trees had a leaf-potassium content of 0.85% that year, compared to 1.47% for the treated trees.

TO FIGHT WINTER INJURY

N-K teamwork may *prevent winter injury!* The way high N prevents full hardening of trees is well known. Present Vineland research indicates high K may influence both tree and bud hardiness. In the winter of 1962-63, more Elberta and Veteran peach fruit buds survived from high K trees. N-K balance seems important here.

Soil type influences N-K nutrition. A survey of peach orchards on three soil types indicated that:

1 On the finest textured soil type, with a higher moisture and nutrient holding capacity, few orchards were low enough in K to give a yield response.

2 On the same soil, higher nitrogen status was associated with higher yield.

3 On the coarser soils, high nitrogen also resulted in increased yield in a normal crop year, but the most striking differences were from high potassium. *On the coarser soil types, trees with a high leaf-potassium value produced from 1.4 to 2 tons per acre more fruit than low-K trees.*

N-K TEAMWORK FOR PEACHES

BY J. A. ARCHIBALD VINELAND STATION, ONTARIO

4 On all three soils, regular manure use caused higher leaf-content of N and K and higher yield than non-manure use.

Peach variety influences N and K requirement. Elberta-type varieties seem to utilize soil potash better. When several hundred adjacent blocks of different varieties were analyzed, Elberta and Golden Jubilee showed consistently higher levels of leaf potassium and lower levels of leaf nitrogen than Redhaven and Veteran trees. Acute K hunger signs appear on Veteran and Redhaven first.

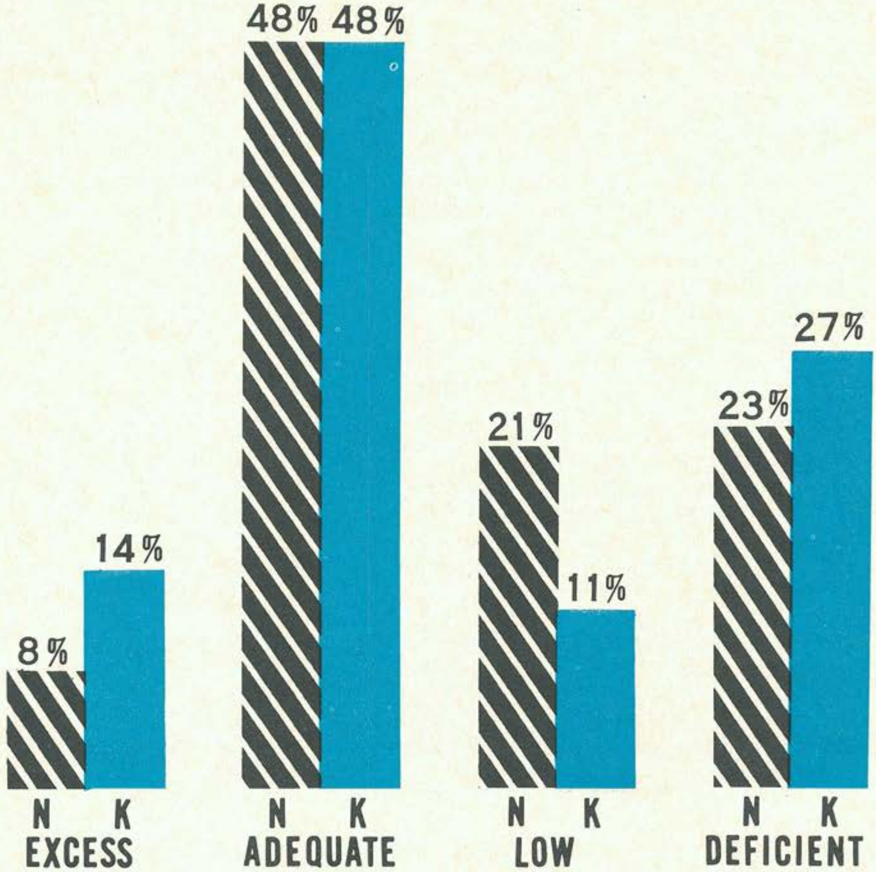


FIGURE 2 **N-K STATUS OF ONTARIO PEACH ORCHARDS**

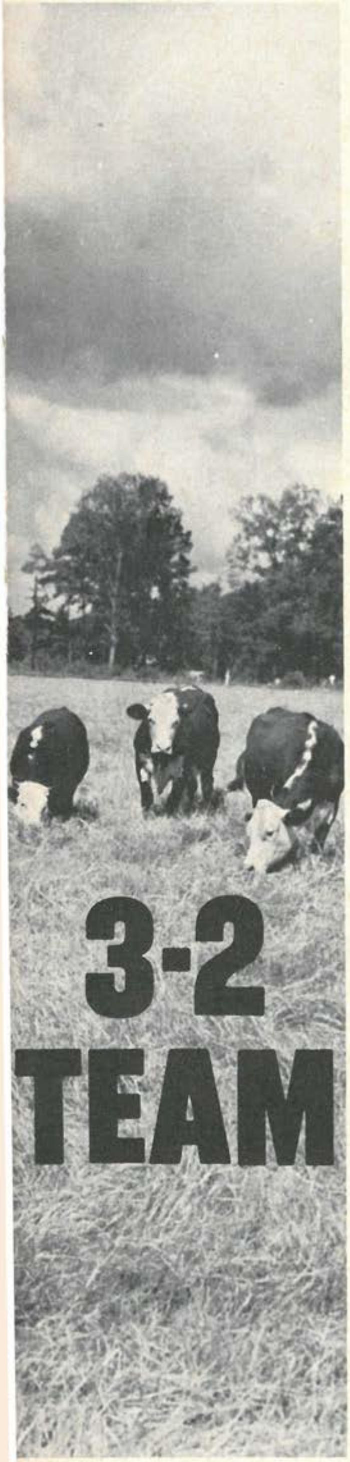
LEAF ANALYSIS TELLS THE STORY

Our research has shown that a balanced high level of N and K produces more peaches and more dollars. Leaf analysis is the best way to determine N-K status.

Ontario has had a leaf-analysis service since 1958. In the period 1960-1964, 370 grower samples were analyzed. Figure 2 shows the results. While most growers realize the importance of adequate N and K, 44% (21 + 23) were below adequate in nitrogen, 38% (11 + 27) below adequate in potassium. Of those deficient in nitrogen, 46% had deficient K levels, while 12% had excessive K. Of those with nitrogen excess, 42% had excess K while 9% were K-deficient.

Poor yields and wasted fertilizer cost the peach grower money. Leaf analysis helps the grower make N-K teamwork pay.

THE END



An experiment was conducted from 1951 through 1956 at Tifton, Georgia, to study the effect of varying fertilizer rates and ratios on the production of Coastal bermudagrass growing on a Tifton loamy sand. An analysis of the data to include yield, chemical composition of the forage, and soil test results led to the following conclusions:

1 The available phosphorus and potassium in the soil were depleted when they were omitted from the fertilizer applied. The rate of depletion increased with increasing rates of nitrogen application.

2 There was no yield response to applied potassium at any N rate the first year of the test. Potassium became the limiting factor in the second year on those plots receiving annual applications of 400 and 800 pounds of nitrogen per acre and no potash.

3 There was no yield response to applied phosphorus at any N rate until the fourth year of the experiment.

4 The induced phosphorus deficiencies were corrected the first year after applying sufficient phosphorus to raise the soil level to approximately 75 pounds of available P_2O_5 per acre and then applying a 4-1-2 ratio based on the N rates used, from 200 to 800 pounds per acre. A 3-1-2 ratio was used for the 100-pound N rate.

5 The induced potassium deficiencies were corrected after applying sufficient K_2O to raise the soil level to approximately 100 pounds of available K_2O per acre and then applying a 4-1-2 or 3-1-2 ratio for two successive years.

6 It appears that the available soil phosphorus and potassium may fall to very low levels before a resultant yield reduction of Coastal bermudagrass would be observed in field plantings. Periodic soil testing is an invaluable tool in determining the amount and ratio of P and K needed for a given management system.

7 For most soils similar to those of the test area, a maintenance fertilizer ratio for Coastal bermudagrass hay production should contain at least 1 unit of P_2O_5 and 2 units of K_2O for each 4 units of nitrogen.

—Agronomy Journal

Turfgrasses are heavy nitrogen and potassium users. To maintain a healthy, beautiful, and vigorous turf, make sure adequate amounts of these two fertilizer elements are supplied throughout the growing season. Phosphorus, of course, is essential to good turf quality, but is required in much smaller amounts than either nitrogen or potassium.

INITIAL FERTILITY LEVELS

Colonial bentgrass was planted on a Puyallup fine sandy loam soil in 1959. Soil tests at establishement time indicated 500 lbs. potassium and 24 lbs. phosphorus per acre, both high for turfgrass growth. The soil pH averaged 5.6.

Nineteen treatments were made up of three levels of nitrogen (870, 522, and 261 lbs./A), two levels of phosphorus (0, 77 lbs./A), and three levels of potassium (0, 145, and 290 lbs./A). The plots have received urea, muriate of potash, and treble superphosphate as the only source of nutrients from the outset. This experimental area has been managed as putting green turf.

NITROGEN-POTASSIUM TEAM ON TURFGRASSES

BY ROY L. GOSS
WASHINGTON STATE UNIVERSITY

TISSUE SAMPLING AND ANALYSIS

Tissue samples and clipping yield data were collected from 6 out of 19 plots (1963 and 64) to determine how much of the applied fertilizer elements were being removed in the clippings. The following plots were selected:

POUNDS PER ACRE*			POUNDS PER 1000 SQ. FT.		
N	P	K	N	P	K
870	77	290	20	1.76	6.64
522	0	0	12	0	0
522	0	145	12	0	3.32
522	0	290	12	0	6.64
522	77	145	12	1.76	3.32
522	77	290	12	1.76	6.64

* Expressed on elemental basis. Original experiment was set up on oxide basis for P and K.

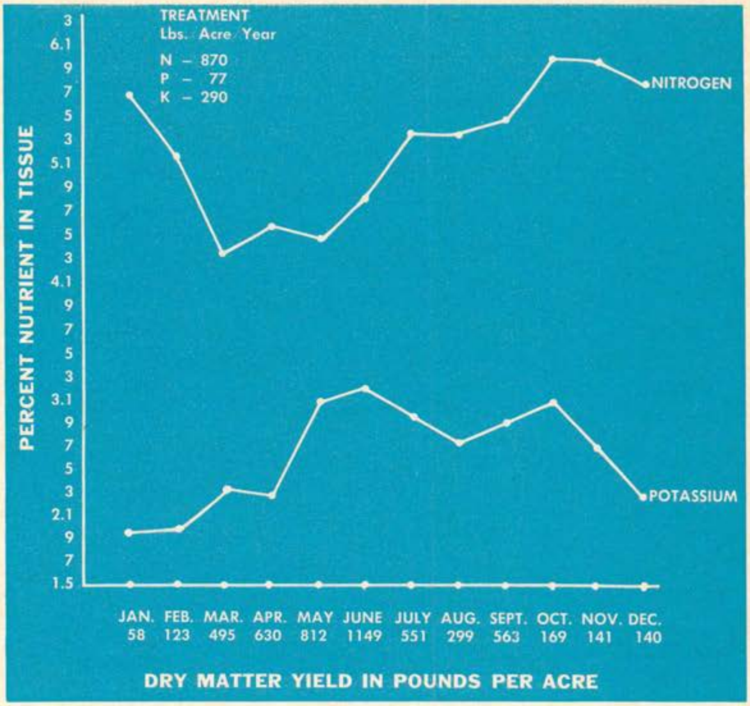


FIGURE 1

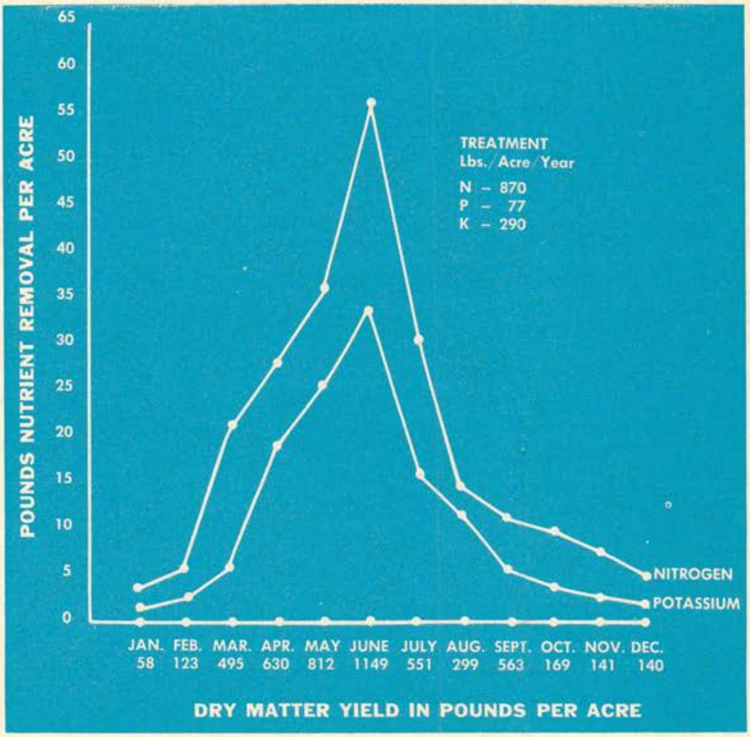


FIGURE 2

TISSUE NITROGEN

The percent tissue nitrogen is highest during the fall and winter months when yields of clippings are lowest. Figure 1 shows the percent tissue nitrogen for each month. Figure 2 shows the same treatment but in pounds of nutrient removal and dry matter yield per acre. Figure 2 shows a 1,149 lbs./A yield in *June* but a nitrogen level of 5%. Compare this to *October* where we have a yield of 169 lbs./A and 6% nitrogen. Peak nitrogen removal is in May and June. Continued high nitrogen fertilization caused some injury and reduced growth during the warmer months of July and August, mentioned later.

Figure 3 shows tissue nitrogen levels where only nitrogen at 522 lbs. per acre per year was applied—and Figure 4 the pounds of nutrient removal per acre. Although tissue nitrogen is high in Figure 3, because of the low total dry matter yield, the nutrient removal is lower than treatments shown in Figures 2 and 6. In Figure 5, the 522-77-290 treatment produced tissue with lower nitrogen levels than the treatment shown in Figure 1. But because of a higher total dry matter yield, there was a high total nutrient removal.

TISSUE POTASSIUM

Tissue potassium is highest during peak growing season and lowest during fall and winter—directly opposite to tissue nitrogen levels. But Figures 1 and 5 reveal that 290 lbs. of K per acre maintain higher tissue K levels than 145 lbs. during fall and winter. Tissue levels of potassium declined only slightly in July where 290 lbs. of K per acre were applied (Figure 5) but declined rather sharply where no K was applied (Figure 3).

NITROGEN-POTASSIUM INTERACTIONS

The most favorable relationship between nitrogen and potassium occurred when 522 lbs. N, 77 lbs. P, and 290 lbs. K per acre were applied. Not only did this treatment (Figures 5 and 6) produce a closer ratio between N and K than the other two treatments, but also a greater total yield of clippings and percentage recovery of these two elements. Here are the six treatments which were analyzed and the pounds of N and K that were recovered per acre for the entire year:

POUNDS OF NITROGEN AND POTASSIUM RECOVERED PER ACRE FROM TURFGRASS CLIPPINGS

FERTILIZER APPLIED PER ACRE	POUNDS N	POUNDS K
870-77-290	224	127
522-77-290	**224**	**137**
522-77-145	223	135
522- 0-290	178	111
522- 0-145	191	107
522- 0- 0	202	105

The treatment receiving 870 lbs. N, 77 lbs. P, and 290 lbs. K per acre was injured during the hot weather from interactions of N and K. Figures 1

FIGURE 3

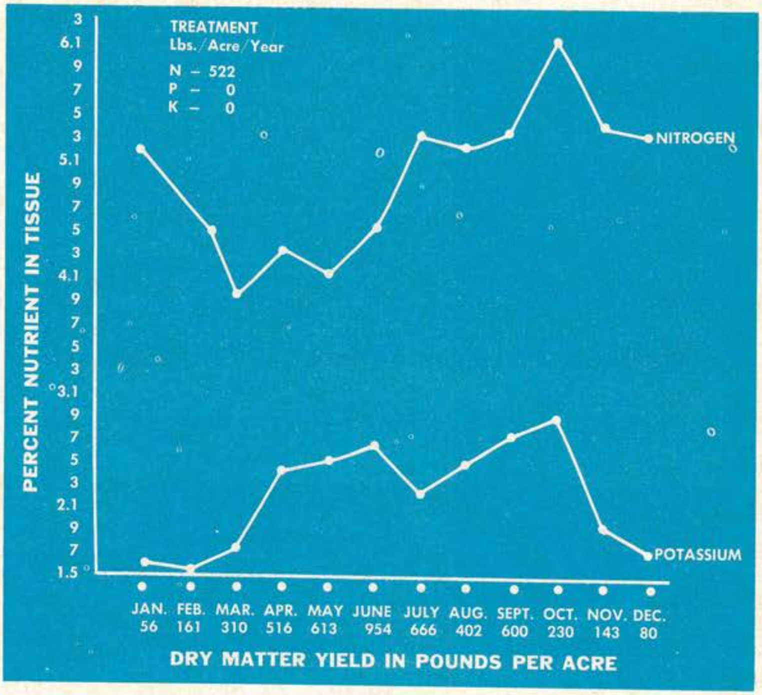


FIGURE 4

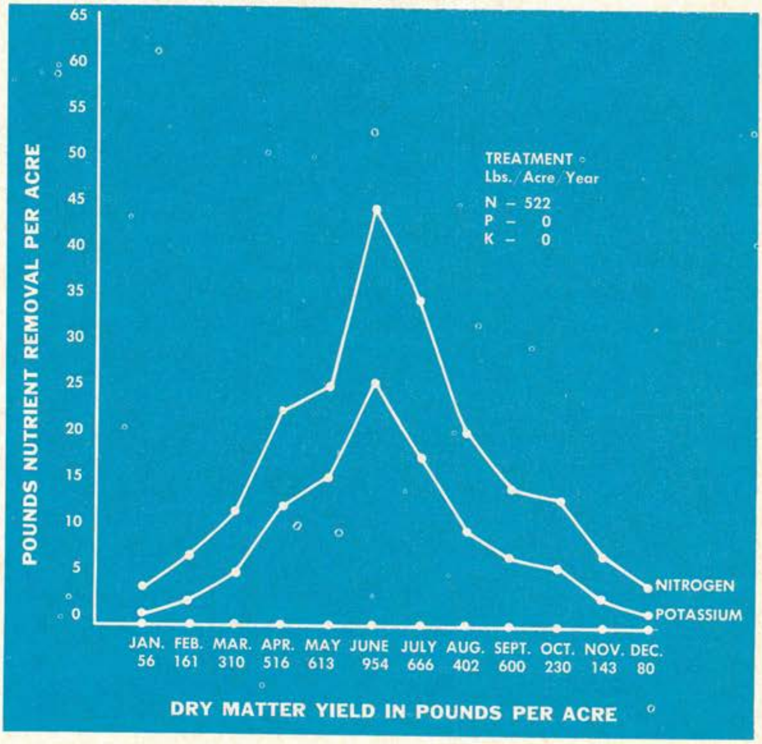
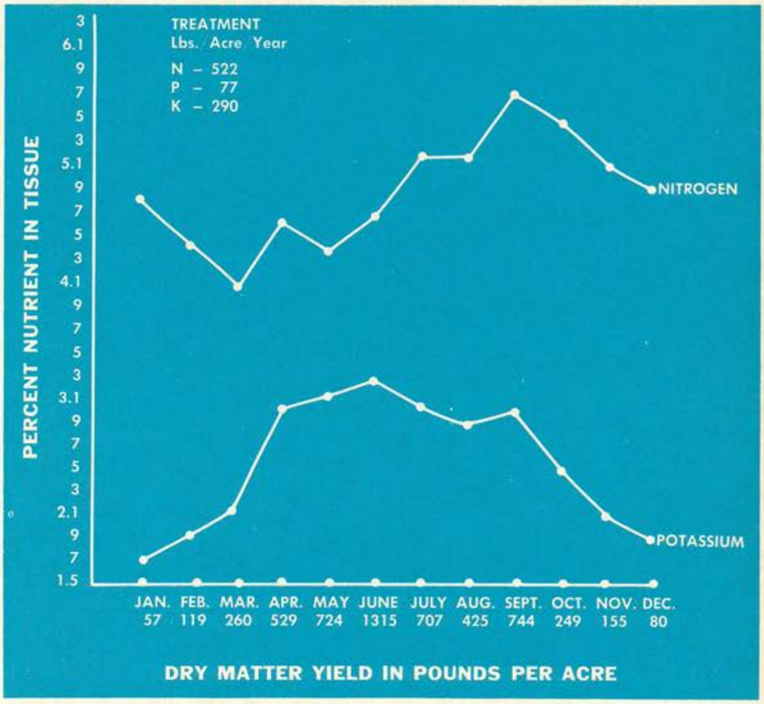


FIGURE 5



and 2 show a depression in dry matter yield during July, August, and September when compared with Figures 5 and 6. Also, this excessively high nitrogen level induced more growth later in the winter season.

Fast growth and high dry matter yields are not entirely desired in turfgrasses but do reflect the vigor of the grass as influenced by treatment.

NITROGEN-POTASSIUM EFFECTS ON DISEASES

Fusarium patch disease (caused by *Fusarium nivale*) increases with increased nitrogen, especially from most organics and synthetic organics.

Ophiobolus patch disease has not been influenced in the same manner. It now appears to be associated more closely with nutritional balance. In cooperative research with Dr. C. J. Gould of this station, the greatest diseased areas have occurred on plots receiving only nitrogen. *The fewest disease spots are found on plots receiving N and K.* As mentioned earlier, P is necessary for normal growth and development, but K appears to be more important in disease control.

WHAT IS IN THE FUTURE?

Future turfgrass fertilizer recommendations in the Pacific Northwest and perhaps other areas can be based on these research findings.

Based on previous soil tests, a standard 3-1-2 ratio recommendation has been used with good success. In the second table of this article, the treat-

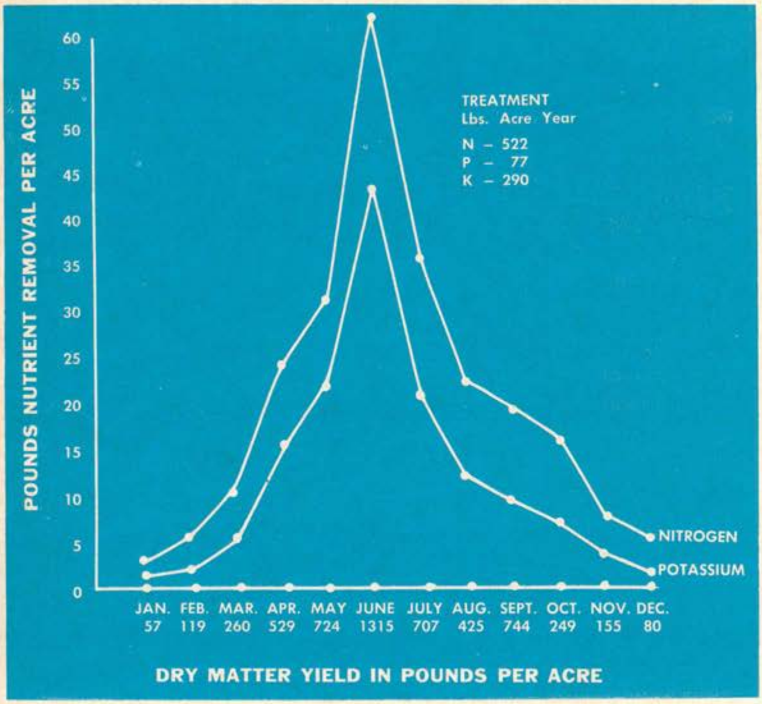


FIGURE 6

ment of 522 lbs. N, 77 lbs. P, and 290 lbs. K (elemental) removed 61% as much potassium as nitrogen.

Future soil tests will show whether soil reserves are being lowered. If so, it may be necessary to increase K applications even higher to prevent depletion and maintain the best turfgrass quality.

THE END

New England dairymen have become more and more aware of what nitrogen fertilizer can do to their grass production.

Intensive fertilization of grasses is becoming regarded by many as a practical means of extending the productive life of forage stands for a few years, following the loss of associated legumes.

We have observed that grass yields in New England may decline sharply after the first year or two, *in spite of continued high usage of nitrogen.* Field examinations and soil tests in Maine have indicated potash starvation may be an important cause of these lowered yields.

However, experimental proof of this likelihood has been lacking until field experiments were started in 1956 to determine the effect of nitrogen usage on the mineral requirements of timothy. Results from these experiments during the past three years indicate one fact—that grasses which receive intensive nitrogen treatment also demand high potash treatment.

HIGH NITROGEN INCREASES POTASH

These and related experiments on grasses in Maine seem to point up certain ways fertilizers may be used to produce grasses on New England soils—intensively, successfully, economically. These pointers are:

1 Timothy and similar grasses have a potential production capacity about equal to alfalfa on soils of good moisture retention. Four tons or higher per acre may be secured in two cuttings of well-fertilized grass hay grown on good loams or silt loams of at least moderate depth. Fertilized grasses grown on these better soils are affected less by drouth than we have previously assumed.

2 Nitrogen requirements for near maximum yields of pure grass stands are *much higher than often recognized.* When clovers or other legumes are absent, about 200 pounds nitrogen a year are usually needed. Grasses managed for pasture may respond to even higher nitrogen levels.

3 Intensive production from grasses requires *split applications of the annual nitrogen topdressing.* It is not practical to use a single massive application of nitrogen in the spring. Luxury consumption of nitrogen, lodging of the hay crop, difficulties in harvesting, and curing can all occur when we fail to subdivide the annual nitrogen treatments.

4 *High nitrogen fertilization increases the annual potash demands of* *grasses*. Failure to increase potash rates may reduce yields greatly just a year after the first intensive nitrogen usage.

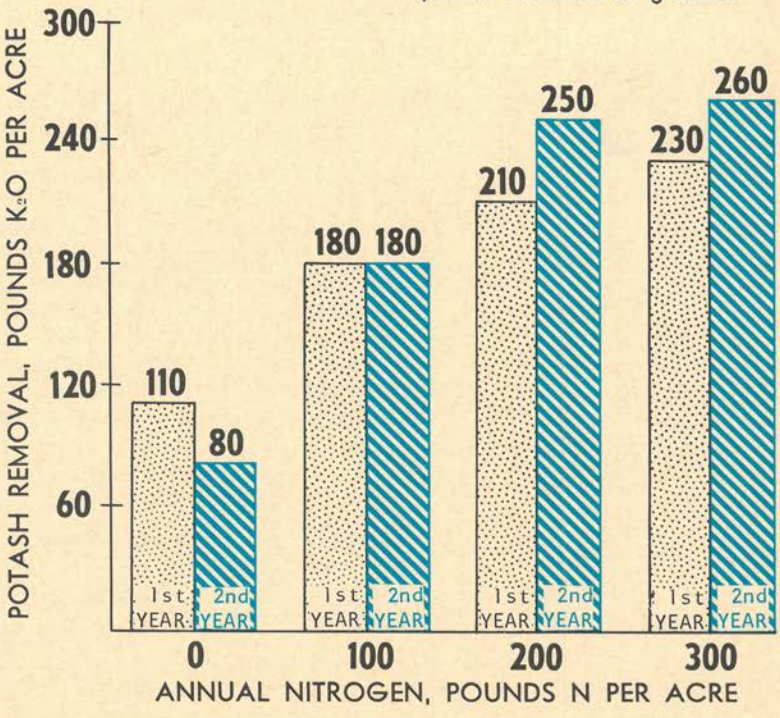
5 The potash requirement of many New England soils seems to be two or three times greater than the phosphorus requirement for topdressing high nitrogen grasses. Using equal amounts of P_2O_5 and K_2O on these soils, as currently practiced, does not appear economically sound. Fertilizers with higher potash content should be used to meet the minimum phosphorus and potash needs of high yielding grasses most economically.

Such findings should encourage more New England dairymen to examine their fertilizer ratios for grasses more carefully in the future.

(Adapted from *Better Crops* reprint DD-11-58, Cecil Brown, University of Maine).

NEEDS OF GRASSES

THE MORE NITROGEN they used the more potash the timothy grass removed from the soil. Note how the timothy receiving 200 lbs. N removed 100 to 150 lbs. more potash annually than the low-N plots. Conclusion: high N rates increase annual potash demands of grasses.

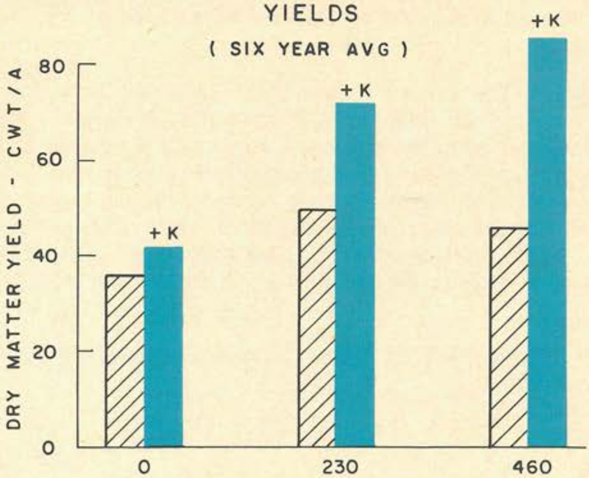


BACK UP YOUR NITROGEN WITH PLENTY OF POTASSIUM

WHY IT PAYS!

NITROGEN AND POTASSIUM TEAMWORK PROVIDE TOP TIMOTHY-RYEGRASS YIELDS

(SIX YEAR AVG)



ANNUAL NITROGEN APPLICATION - LB/A
(UNITED KINGDOM)

1 BECAUSE N & K WORK TOGETHER

Results from many quarters show how plant foods work together to benefit the production of crops. Figure 1 indicates the positive benefits in forage yields when N and K are used together.

2 BECAUSE ENOUGH N CAN MAKE EXTRA K PAY ON HIGH-K SOILS

North Dakota results (below) point to the fact that early seeded barley may respond to applications of row potassium on soils testing very high in exchangeable K (300 and 400 lb./A.) when applied in combination with nitrogen and phosphorus. The first level of nitrogen and potassium produced an apparent positive N-K interaction. Indications from these and other trials are that K may also increase the percent plump kernels.

Gardena Loam
Row P—17 lb./A.

Bct. N	Row K—lb./A		
lb./A.	O bu.	12.5 bu.	25.0 bu.
0	35.6	35.0	39.9
30	40.6	47.1	44.0
60	**44.6**	**47.7**	**47.9**

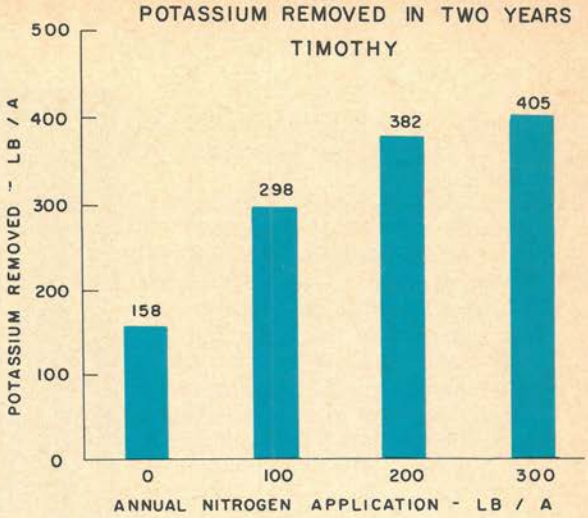
ADAPTED FROM MIDWEST POTASH NEWSLETTER

3 BECAUSE N BOOSTS K REMOVAL

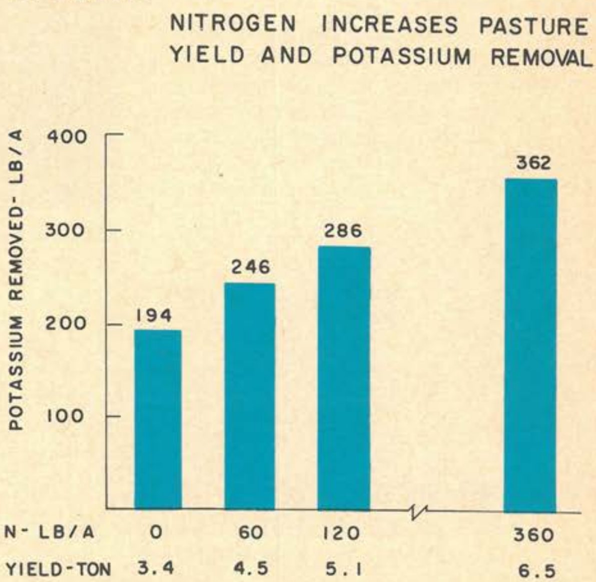
. . . both soil & fertilizer K

N boosts yields of grasses but also boosts K removal.

Results from across the U.S. indicate that N applications influence K removal. Need for additional K may be present even when yields are not increased, because of feed quality factors. Over 700 lb. of muriate of potash per acre per year would be required to replace that removed at the 6.5 ton yield level in the Washington trial. High yields of corn silage also remove high amounts of plant food.



IN MAINE



IN WASHINGTON

. . . under different management systems

Many have been interested in K removals under different management. Data from Rothamsted, England provide some answers for various situations. The highest removal amounts to 180 lb. of K per acre per year. Because rates of recovery are about 50 to 60 percent, even more K would have to be applied on soils with low supplying capacity.

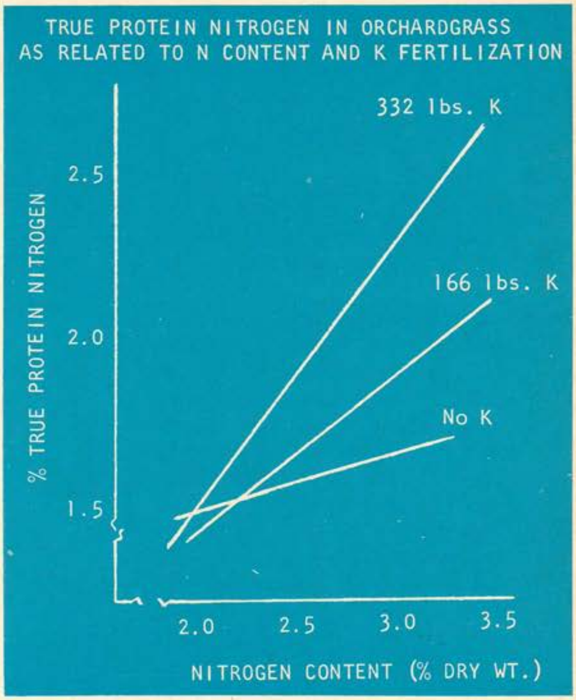
AT ROTHAMSTEAD, ENGLAND

Management	K Removed in 3 years lb./A.
Grass cut and removed	540
Cut for hay, aftermath grazed	456
Lucerne cut for hay	374
Grazed continuously	208
Seed, potatoes and oats rotation	186

4 BECAUSE K INCREASES PROTEIN FORMATION

Research at Purdue University shows that potassium fertilization promotes protein synthesis and often prevents the accumulation of non-protein nitrogen in grasses and legumes. The percent true protein increased in orchardgrass as the level of applied K is increased. Under low and medium levels of soil K and high N, non-protein nitrogen accumulates, which appears to reduce the quality and palatability of grasses.

These are factors which still need evaluating. By focusing attention only on yields, one may miss important quality considerations.



5 BECAUSE N-P-K "BALANCE" REDUCES STALK ROT AND LEAF BLIGHT

Proper nutrition of corn reduces stalk rot and corn leaf blight (Illinois). There are some indications that the chloride in muriate of potash may be involved in reducing diseases in crops. Chlorine is another element essential to plant growth, although it is needed only in small quantities.

Effects of Fertilizer Applications on Corn Yields and Stalk Rot

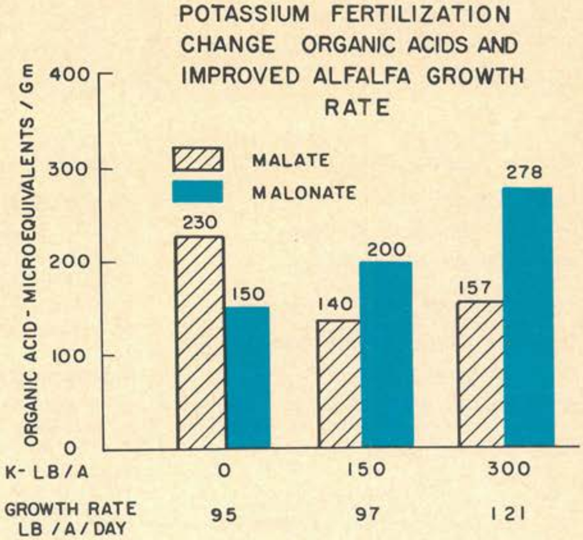
Spring Plow-down			Corn Yield	Rot Damaged Stalks
N lb.	P_2O_5 lb.	K_2O lb.	bu.	%
0	0	0	80	16
80	0	0	84	40
0	80	0	84	21
0	0	80	88	17
0	80	80	85	13
80	80	0	76	49
80	**80**	**80**	**110**	**17**

Effect of N and K on corn leaf blight (Lime & Phosphate plots) Degree of leaf blight infection

		K_2O—lb./A 0	25	50
N - lb./A	0	4.8*	3.2	**1.5**
	40	4.8	3.0	**3.2**
	80	4.2	2.8	**2.2**

* 1.0 = no leaf blight, 5.0 = lesions on all leaves.

WHY DOES EXTRA N DEMAND EXTRA K?



Nitrogen increases yields, which means greater removal of other plant nutrients. However, there are other less obvious relationships involved. Nitrogen content of crops influences the ability of roots to take up plant food. Research has shown that crops having a high nitrogen content have roots with high exchange capacities (ability to hold many positively charged ions) and have a much stronger attraction (bonding energy) for calcium (Ca) and other divalent cations, than for K (legumes such as alfalfa and soybeans).

For crops with roots of low exchange capacities, such as grasses, the attraction for Ca is less, while attraction for K is relatively high. With applications of N, the exchange capacities of grass roots increase, leading to a relatively greater uptake of Ca. Under high levels of N, which is needed for high production, higher levels of available K might have to be maintained to provide crops with adequate K.

Such relations are involved in maintaining legume stands in legume-grass mixtures and may provide part of the answer as to why alfalfa needs high levels of available K. Other factors included in legume-grass interrelationships may be the type of root systems (grass = shallow fibrous; legume = deep tap) and the relatively slow movement of K to roots, once the enriched zone about the root system has been depleted in the spring.

Also, organic acids produced in crops often increase under high levels of N. Potassium is the major metal ion used in neutralizing these acids. Potassium also may metabolically influence the kinds of acids produced in grasses and legumes.

Research in Indiana with second crop alfalfa grown on a soil testing medium in K (125-150 lb.) indicates how the contents of certain organic acids shift as adequate K is applied. What these changes may mean to cattle in terms of intake and feeding value remains to be evaluated.

THE END

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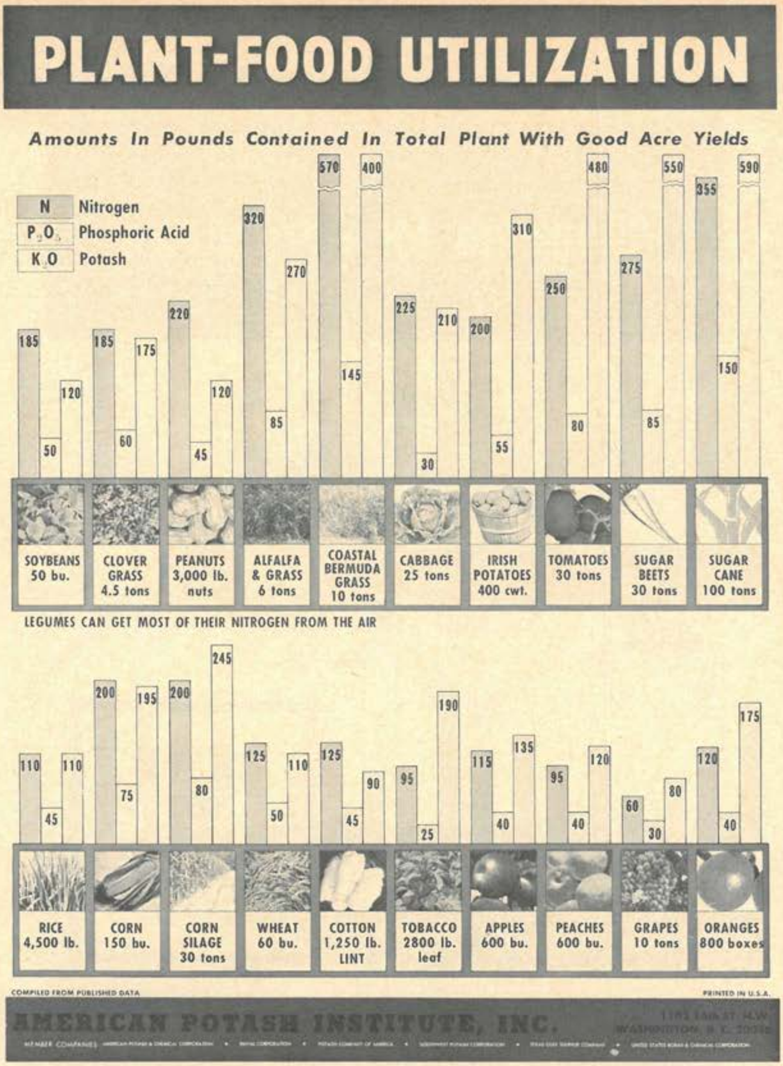

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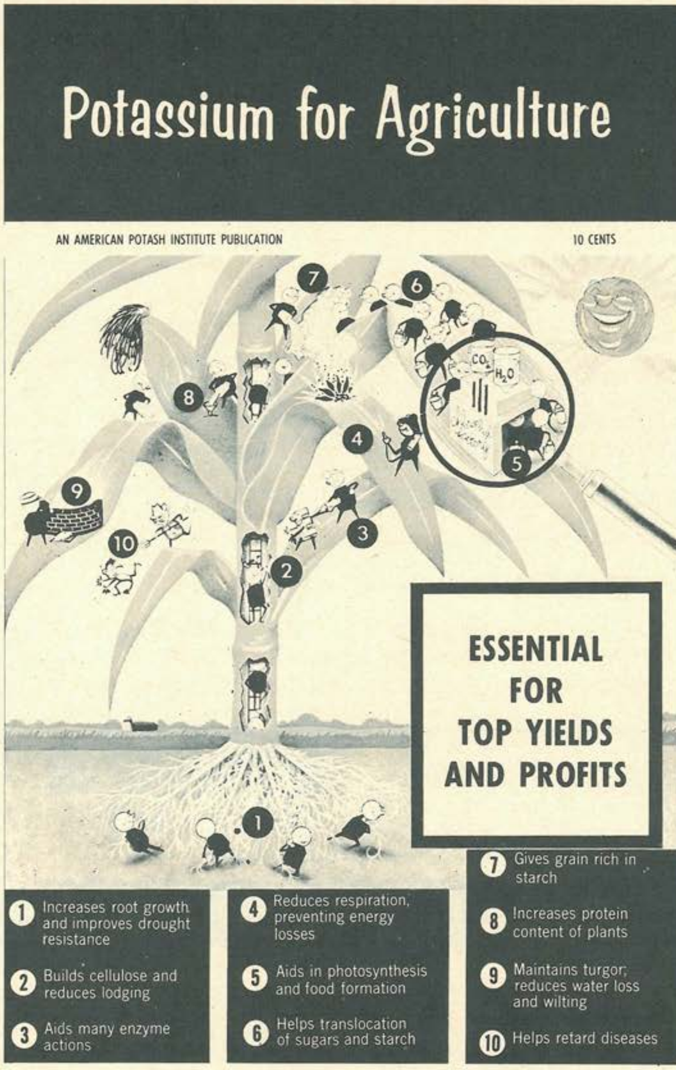
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