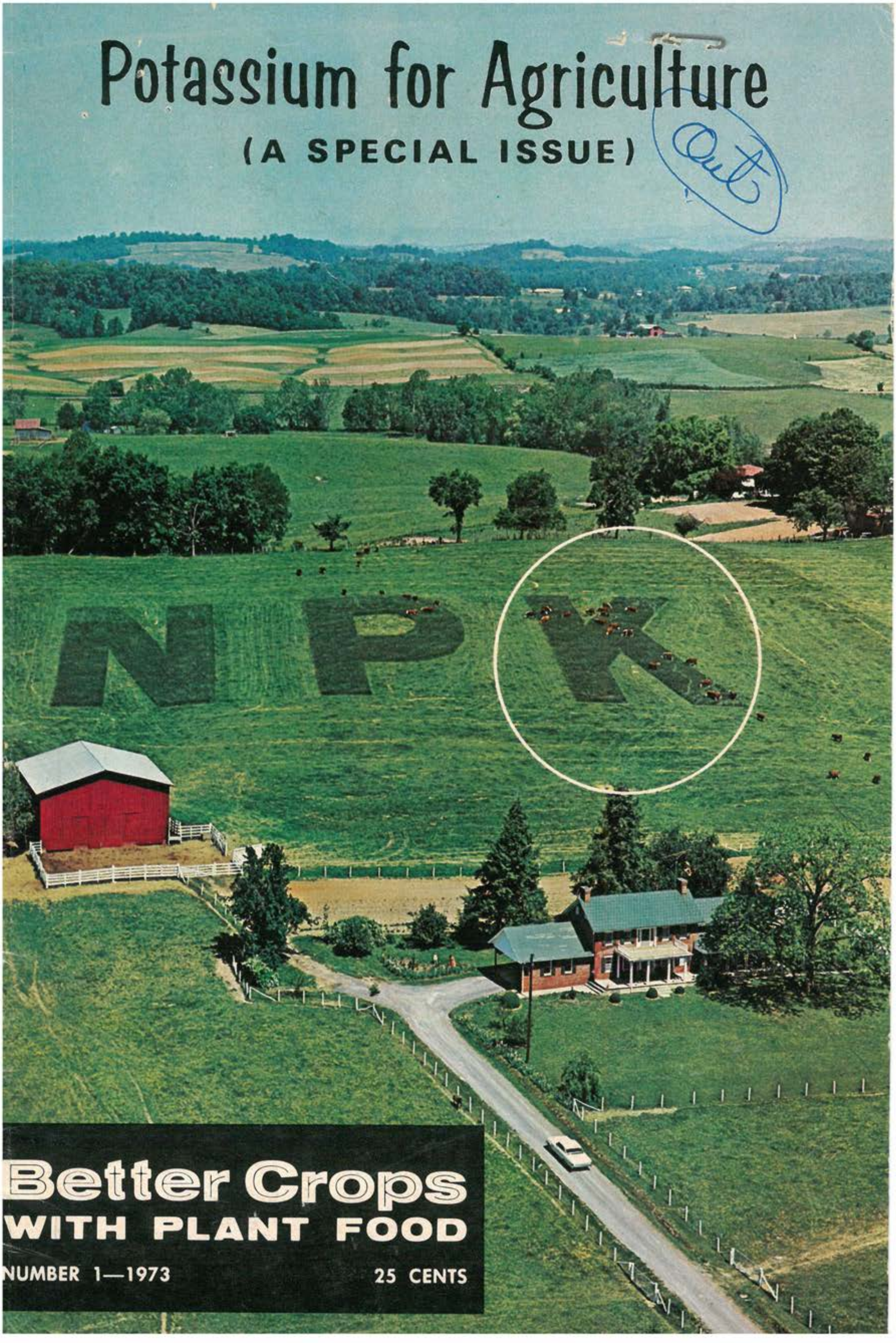
Potassium for Agriculture

(A SPECIAL ISSUE)



Better Crops WITH PLANT FOOD

NUMBER 1—1973 25 CENTS

Better Crops
WITH PLANT FOOD

Published Quarterly by
Potash Institute of North America
1649 Tullie Circle, N.E.
Atlanta, Georgia 30329

Santford Martin, Editor
Selma Bushman, Assistant Editor

Vol. LVII/1/73

$1.00 per year, 25¢ Per Copy

Controlled circulation postage paid at Washington, D.C.

Cover picture, courtesy PROGRESSIVE FARMER magazine, shows 3 major chemical symbols of mixed fertilizers—(N) nitrogen, (P) phosphorus, (K) potassium—spelling what fertilizer means. The letters got plenty of NPK, the rest of the pasture none for this trial on Clyde Carter's Tennessee farm.

1—Where does potassium come from and how is it produced today?

IF AMERICA'S FARMS had to get the potash they need today from the late Samuel Hopkins of Puttsford, Vt., we could say goodbye to 17,500,000 acres of choice hardwood each year. His process used 5 acres of timber to produce one ton of potash. The FIRST U. S. government patent, issued in 1790, went to his potash making process. It was signed by President George Washington.

No one knows how much timber the Jamestown colonists used to get the potash necessary for soap, glass, and gunpowder of their day. We do know one of their first industries was making potash from wood ashes to sell abroad. They had no idea it was vital to plant life. Neither did Hopkins 180 years later.

Potassium's plant food role was not discovered until 1840 by German chemist Liebig. Soon thereafter the earth's first potash deposits were mined in Germany.

Until World War 1, the American farmer depended solely on imported potash, consuming 250,000 tons a year by 1914—most of it on soils in the South and East where profitable crops depended on potash fertilization.

When the war cut off our supply and prices raced from $50 to $500 a ton, America turned to partly dried-up lakes in the arid West to produce enough potash to keep going. By 1918, around 128 small potash-producing plants were getting more than 50,000 tons from

Making "Pott-ashes" at Jamestown, 1608

these sources. But after the war, imports and normal prices closed all but one of these war-born plants.

NORTH AMERICAN DEPOSITS . . . IN NEW MEXICO. Drilling for oil in 1925, engineers found potash deposits 800 to 1800 feet down, in former sea bodies that had dried up and deposited the potassium. By 1931, the first potash was produced from these deposits. In the vicinity of Carlsbad, New Mexico, several companies are today producing potassium chloride, potassium sulphate, and potassium magnesium sulphate for agriculture and industry.

IN CALIFORNIA. The only plant to survive World War 1 was at Searles Lake, a partly dried saline lake in the Mohave Desert. Here potassium chloride and potassium sulphate are produced from brines.

IN UTAH. Since 1938, potash has been produced from the brines of the Salduro Marshes at Wendover by a process involving solar evaporation. Still another company near Ogden uses solar evaporation to produce potassium sulphate from the Great Salt Lake. Utah also contains a large underground deposit, about 3,000 feet down. Potassium chloride production began here in 1965 using conventional shaft mining, later changing to solution mining along with solar evaporation.

IN CANADA. Saskatchewan Province contains very large potash deposits about 3,000 to 5,000 feet deep, important because of their size and purity. Potassium chloride began here in 1959. Now several U.S. and Canadian firms have made Canada one of the great potash producing nations of the world.

Many people ask where potash is produced on the earth. In addition to these North American sources, potash is produced in Germany, the first nation to discover it . . . in France . . . Spain . . . the Dead Sea . . . Poland . . . Russia . . . Italy . . . and more recently in the Congo in Africa.

In soils and fertilizers, potassium is found combined with other elements. When combined with chlorine, potassium forms the compound potassium chloride (KCl) which is called "muriate of potash."

Due to custom and state laws, the potassium content of fertilizers is usually given in terms of K_2O (potassium oxide) and called "potash" even though there is actually no K_2O in the material. The chemist analyzes the fertilizer, finds out how much K is present, and calculates this to the equivalent amount of K_2O.

This custom is changing in some states and the potassium content of fertilizers is being given in terms of potassium or K as well as "potash" or K_2O. To convert K_2O to K multiply by 0.83.

The term "potash" is used frequently in this publication, but also the word potassium or the letter K is used. Where there are tables on response or figures on removal, K_2O is used.

...AND TODAY

A BRIEF LOOK at methods of producing potassium will give an idea of how this North American industry produces some of the finest quality potassium in the world today.

UNDERGROUND MINING. The largest percentage of potassium is mined this way with great hydraulic and automatic continuous mining machines cutting up to 5 tons of ore per minute. This ore is called sylvinite, a physical mixture of coarse crystals of sylvite (KCl) and halite ($NaCl$) intermingled with clay and small amounts of impurities.

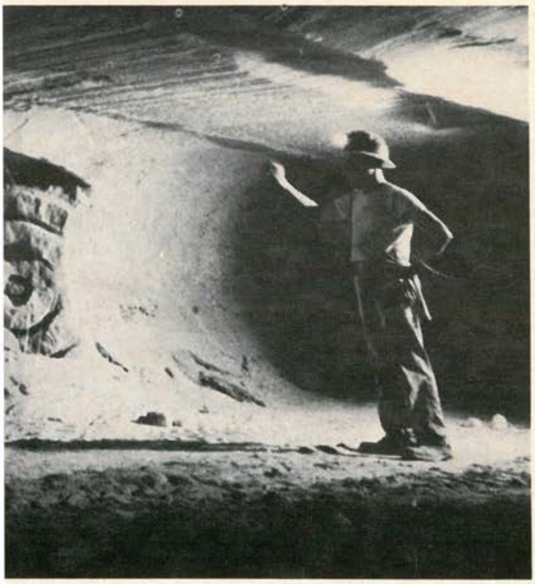
The mining process creates many miles of underground tunnels and rooms. Miners transport the ore to the big central shaft by belt or rail. Up the central shaft, huge hoists lift skips filled with several tons of ore on each trip. There is also a shaft for the men, air, electricity, and equipment.

The refinery (with processing equipment, labs, offices, storage, and rail facilities) receives the ore above the mine. The refinery team first crushes and screens the ore. Then they separate the sylvite (KCl) from the clay, the halite ($NaCl$), and other impurities through flotation cells.

Another refining process uses crystallization, taking advantage of the difference in solubility of KCl and $NaCl$.

SOLUTION MINING. Potassium-bearing minerals may also be brought out in solution. A hole is sunk into the mineral bed and a liquid pumped down to dissolve the minerals. Then the potassium is brought up in the fluid to be concentrated and refined.

BRINES AND LAKES. Potassium products are being produced from natural brines at Searles Lake, California, and from the Bonneville Salt Flats in Utah. The raw brine solution is concentrated by forced evap-



oration or solar evaporation and then refined. From the Great Salt Lake in Utah, potassium sulphate is produced by concentration of salts in solar evaporation ponds before refining.

THE POTASH INDUSTRY produces various potassium compounds in different sizes and grades to meet the needs of agriculture and industry.

Muriate of Potash (KCl) is the leading potassium material used in fertilizer . . . runs 96 to 99% potassium chloride . . . (60 to 62.5% K_2O equivalent). It is produced from the sylvinite ore in Carlsbad and Saskatchewan and from the brines in California and Utah.

Sulphate of Potash (K_2SO_4) is produced by treating muriate of potash with acids or neutral salts. It is also extracted from the mineral, langbeinite, in the Carlsbad area and produced by using solar evaporation at Salt Lake City. It runs 92.5 to 96% K_2SO_4 . . . (50 to 53% K_2O equivalent) . . . contains about 18% S (sulphur).

Potassium Nitrate (KNO_3) is produced by treating muriate of potash with nitric acid and contains over 13% N and 44% K_2O.

Sulphate of Potash Magnesia (K_2SO_4-$MgSO_4$) is produced from the mineral langbeinite in the Carlsbad area. It is a source of potassium, magnesium and sulphur and usually containing a minimum of 22% K_2O, 18% MgO, and 22% sulphur.

Sodium Nitrate and Potassium Nitrate ($NaNo_3.KNO_3$) is a natural combination of sodium nitrate and potassium nitrate produced in Chile. It usually contains 15% N and 14% K_2O.

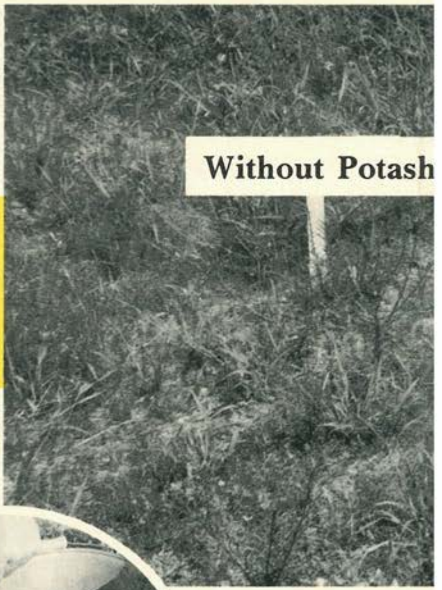
Potassium Hydroxide (KOH), or caustic potash, made by the electrolysis of potassium chloride brine, contains approximately 83% K_2O. Restricted use in liquid fertilizers and in preparing various potassium phosphates and potassium carbonate.

Potassium Carbonate (K_2CO_3) is made in the U.S. by treating caustic potash with carbon dioxide gas. May also be made by leaching wood or plant ashes with water, evaporating and calcining the residue. May contain as much as 68% K_2O. Only small quantities used as a fertilizer source of potash.

Potassium Phosphates differ in solubility from some that are completely water-soluble to some that are quite insoluble. Even those insoluble in water could be used as fertilizers when the phosphorus and potassium are slowly available to plants and yet will not wash out of the soil. Potassium phosphates include potassium metaphosphates, potassium pyrophosphates, potassium polyphosphates and potassium orthophosphates. These products contain 25 to 50% K_2O and also 30 to 60% P_2O_5.

Other Potash Materials include industrial wastes—such as tobacco stems, wool waste, sugar beet factory waste, flue-dust, etc.

2—Can growers tell when they need potassium and how?

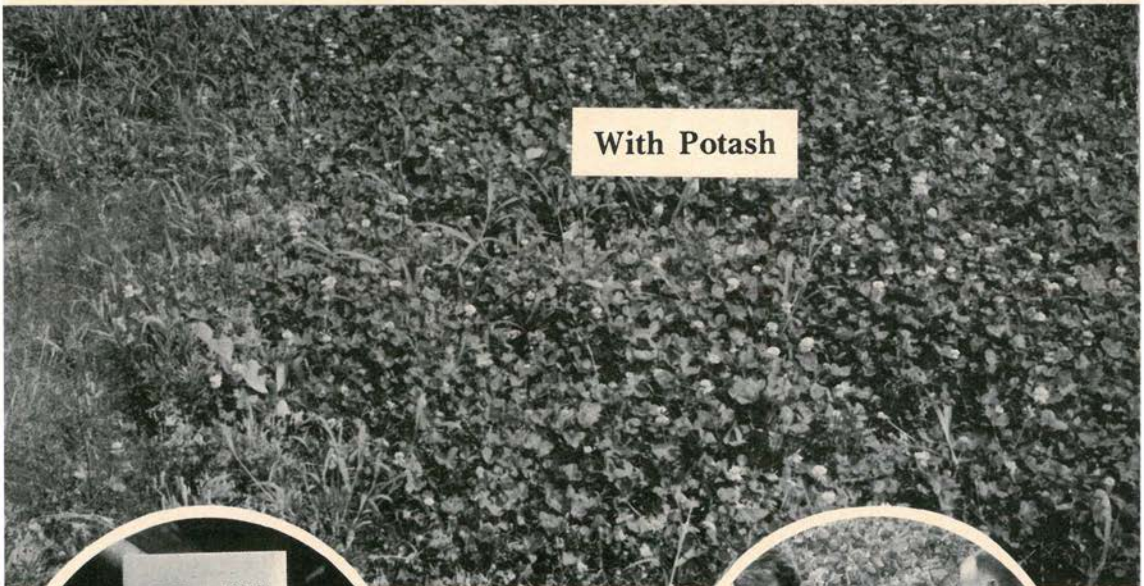


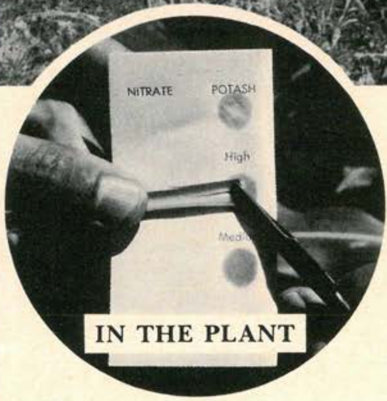
FARMERS SOMETIMES BLAME the weather or "disease" for what potassium hunger did to their crops. They may not associate low potassium with lodged corn . . . delayed soybean maturity . . . dwarfed cotton bolls . . . sluggish alfalfa yields . . . UNTIL scientific tests convince them. Such tests may detect the problem in the soil or in the overall plant or even in the plant's conductive tissues.

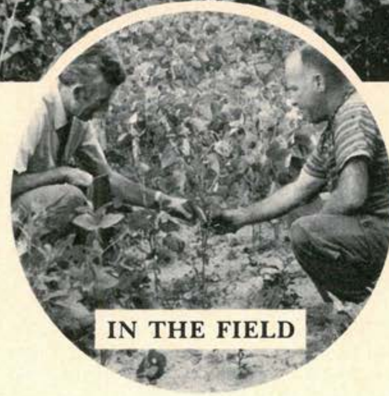
The standard test is the field trial . . . to learn how much plant food (including potassium) is needed for top-profit yields. But a field trial on every field on every farm is not practical. And field trial results on one farm may not apply to farms in the same general area because of soil or man-made differences. So, chemical tests help farmers determine their potash needs.

SCIENTISTS CAN TEST THE SOIL . . .

. . . to tell a farmer how much potassium is there. They use a chemical that







extracts the AVAILABLE potassium in a given sample. Soil potassium can be classified into three categories:

1—Relatively unavailable potassium . . . representing 90-98% of our total K . . . locked in insoluble primary minerals that release far too little to help growing crops.

2—Slowly available potassium . . . representing 1-10% of our total K . . . dissolved from primary minerals or potassium fertilizer and attached to surface of clay minerals and organic matter . . . but trapped between layers of clay minerals and released only by weathering.

3—Readily available potassium . . . representing only 0.1-2% of total K present . . . held on edges of clay and organic matter or already dissolved in soil solution where it may be taken up by plant roots.

If today's high-yield crops had to wait on weathering processes to release the potassium they need THIS SEASON, our food supply would be in trouble. The change to the most available form of potassium is usually too slow to meet the needs. That is why potassium fertilizers are so vital.

SCIENTISTS CAN TEST THE PLANT . . .

. . . to tell a farmer how much of the potassium in the soil actually got into the plant. Plant tests may not always agree with soil tests. If you try to grow corn on a soil low in nitrogen, for example, there may be enough nitrogen to start the plant growing temporarily. But when the nitrogen runs short, other nutrients start building up in the plant. Potassium could build up enough to test high in the plant while it tested deficient in earlier soil tests. In like manner, a soil may test medium or high in potassium, but the plant tests low because the crop could not get enough potassium because of a restricted root system, dry weather or other basic nutrients competing with potassium for entry into the plant.

Scientists use two types of plant tests—tissue tests in the field and plant analyses in the laboratory:

1—Tissue tests on fresh plants can be run quickly in the field. These tests tell the farmer how much potassium is concentrated in the cell sap, not the total amount in the plant. A well-nourished plant usually carries a reserve of nutrients in its conductive tissues. With a kit of test papers, chemical solutions and powders, vials, extracting pliers and knife, the professional tester gets results you can SEE right there beside the crop.

2—Plant analyses can determine total potassium (or other plant nutrients) on the dried plant material by careful laboratory tests. The plant leaf or petiole is most commonly used because it is such a vital plant part . . . and a great tool for finding potassium hunger in tree crops, vine crops, truck and field crops, such as fruits, nuts, grapes, potatoes, and cotton.

SCIENTISTS CAN LOOK AT THE PLANT . . .

. . . to tell a farmer what's wrong SOMETIMES. But the top farmer knows plants can die or disappear from a field without visible deficiency signs reaching his attention. He is much more conscious of HIDDEN hunger today than ever before. If a field growing grasses and legumes is allowed to run low in potassium, the legumes may die out with few obvious hunger signs. Hidden hunger can hit corn plants also. They may have a healthy look, dark green from plenty of nitrogen. But growth is not really vigorous—in fact, slow. Then the root system may show shallow roots from prolonged wet period. This prevented the soil profile from supplying enough potassium for the slow-moving roots to reach out for more needed potassium.

Visible potassium deficiency is seldom encountered in modern farming. Yet, even in this high-yield, hunger-conscious age, 67% of the soil samples received by one state university showed a need for potassium . . . 60% of 1,201 locations in another state the same need. In a third state, 27% of the corn samples, 18% of the soybeans, and 33% of the alfalfa needed potassium.

While deficiency symptoms are uncommon on good farms, the quality of the crop may reflect the lack of enough potassium. In the table of potassium hunger signs in certain crops (opposite page) note how many are associated with quality.

POTASSIUM HUNGER SIGNS IN SOME CROPS

CORN	• Firing or scorching on outer edge of leaf, while midrib remains green. May be some yellow striping on lower leaves. (Sorghum & most grasses also react this way.) Poor root development, defective nodal tissues, unfilled-chaffy ears, stalk lodging.
SOYBEANS	• Firing or scorching begins on outer edge of leaf. When leaf tissue dies, leaf edges become broken & ragged . . . delayed maturity and slow defoliation . . . shriveled, much less uniform beans, many worthless.
COTTON	• Cotton "rust" . . . first a yellowish white mottling in the leaf, clearest between veins. Leaf turns yellowish green, brown specks at tip around margin and between veins. As breakdown progresses, whole leaf becomes reddish brown, dies, sheds prematurely. Short plants with fewer, smaller bolls of short, weak fibers.
WHEAT	• No outstanding hunger signs on leaf itself (no discoloration, scorching, or mottling), but sharp difference in plant size and number, length, and condition of roots. Lodging tendency. Smaller kernels.
ALFALFA	• First signs small white or yellowish dots around outer edges of leaves . . . then edges turn yellow and tissue dies and becomes brown & dry.
CLOVERS	• First signs white spots size of small pinheads near the border of leaves . . . later toward center . . . while border turns yellow, curls up, & dies. The spots appear first on the older leaves. Slower regrowth.
FRUIT TREE CROPS	• Yellowish green leaves curl upward along entire leaf . . . scorched areas develop along edges that become ragged. Undersized fruit dropping prematurely. Poor storage, shipping, & canning qualities in fruit.
POTATOES	• Upper leaves usually smaller, crinkled, & darker green than normal . . . middle to lower leaves marginal scorch & yellowing. Early indicator: dark green, crinkled leaves, though varieties differ in normal leaf color-texture.
TOMATOES	• Stunted plants, slow growth, older leaves ashen gray green with yellowish brown margins . . . small fruit, darkened stem ends from poor attachments to the plant, cracking of flesh around stems, poor uneven color externally and internally.

3—What are the best ways to apply potassium and when?

POTASSIUM CAN BE APPLIED in many ways and at many times. But it pays to remember one big point: To keep adequate amounts of potassium in the soil so the plants can take it up **when they need it.** Broadcasting is the best way to get on large amounts. Band application at planting is important with lower rates or cool, wet conditions.

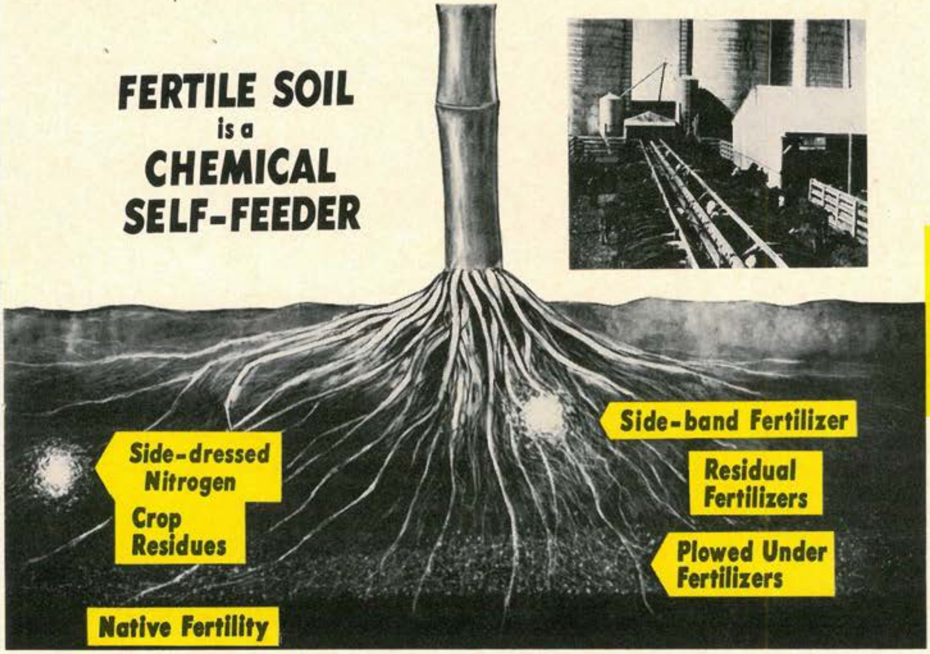
Three factors help farmers decide how to apply potassium: (1) The soil's fertility level. (2) The crop itself. (3) The tillage system they use. To help correct low fertility, some broadcast heavy rates of potassium and plow it down. Annual maintenance applications—to replace yearly losses from crop removal, fixation, and soil-water movement—can be plowed down or placed in bands at planting or both.

Today's trend toward deeper plowing in some areas has enlarged the root zone or plowlayer to be fertilized. This requires proportionately more potassium to fertilize the enlarged area. Many who practice the conventional plowing system have found plowing down potassium works much better than discing it in.

With no-tillage and plenty of crop residues, potassium broadcast on the surface works fine **in humid regions.** Plant roots are dense enough near the surface because of the moist condition under the crop residues. Some farmers broadcast and chisel in the potassium. Before starting these practices, it pays to do two things, if possible:**(1) Build up soil fertility if it is low. (2) Plow every three years or so because potassium accumulates on the surface.**

A good farmer can apply enough potash one year to take care of next year's crop—such as, corn followed by soybeans. The key is to apply ENOUGH potash. Enough to replace not only what the grain or forage of crops remove, but also the additional losses from fixation and soil-water movement, etc. Few farmers may realize it, but roots contact less than 3% of the soil particles to which potassium clings. This means most of the potassium must reach the roots through the water films around the particles.

FERTILE SOIL is a CHEMICAL SELF-FEEDER



Potassium moves very little and very slowly—**under dry conditions.** Poor soil aeration (breathing) badly hinders potassium uptake—**under wet conditions or badly compacted conditions.** So, the need for keeping plenty of potassium in the root zone for such stress periods—too wet, too dry, too compacted—cannot be overemphasized IF THE PLANT IS TO GET WHAT IT NEEDS.

Forages have been called "unique crops" because they can use annual surface applications of potassium very effectively.

Potassium can be applied at the farmer's convenience. This is one of the advantages of this nutrient. It is a real convenience to busy farmers. They can apply it any time during the year their fields permit. It clings to every soil particle but the most sandy. And heavy residues or plant cover can prevent losses on sloping fields.

As potassium levels increase in the soil, when, where, and how it is applied decrease in importance. Broadcast application is a simple way to get the job done fully and quickly.

To be a real profit-maker, your soil must serve your crop like those self-feeder systems serve livestock. When the animal is hungry, the feed is always there. When the crop is hungry, the nutrients should always be there . . . in the right place . . . at the right time . . . in the right amounts. It's the best investment a farmer can make, many believe.

4—How does potassium win yields and influence crops for better farming profits?

WITHOUT POTASSIUM, there would be no life—no human, animal, or plant life. It is basic to life processes. Under normal conditions, plants can absorb K easily. Potassium is very mobile inside the plant, moving readily from older tissues to the growing points. But unlike nitrogen, phosphorus, and most vital nutrients, it does not become part of the chemical structure of the plant. A big part of K exists in the cell sap in soluble form. From there it influences crops in many ways.

Because it does, potassium has been called many things: A chemical traffic policeman . . . a root booster . . . a stalk strengthener . . . a food former . . . an enzyme activator . . . a breathing regulator . . . a water stretcher . . . a sugar and starch transporter . . . a protein builder . . . a wilt reducer . . . a disease retarder . . . etc. Some get carried away and say it puts muscle into plants. Research has shown crops that get enough of it can face stress better.

But potassium is nothing without its brother nutrients, such as nitrogen and phosphorus, magnesium and sulphur. The elements work TOGETHER to build crop yields and quality . . . because success is in the balance. Potassium's influence on growth is seldom obvious to the eye. It doesn't usually cause plant life to show quick spurts of rich-green growth, but it can quietly push the plant toward early maturity . . . and do many other things to win yields and influence crops. The next few pages show why plenty of potassium is essential in a well balanced fertilizer program.

"High potassium rates improve the plant's use of higher nitrogen rates to get more true protein, as well as better yields."

TRUE PROTEIN NITROGEN rose 56% in orchardgrass—from a low 1.6% with no potassium to more than 2.5% with 400 lbs. (K_2O) potassium. Without K, much useless non-protein nitrogen could have accumulated in that grass—not only useless, but potentially harmful to animal health.

Potassium helps corn the same way. Without K, the lower nodes of a corn silage crop receiving 160 lbs nitrogen and 160 lbs phosphorus tested 31% soluble non-protein nitrogen (of the total nitrogen) at harvest. When

When crops receive high nitrogen rate, potassium must be kept in balance. . .

. . . because quantity and quality are at stake. Potassium reduces chaffy ears and lodged stalks—but much more. K reduces non-protein nitrogen that can build up in high-nitrogen corn and forages—in one case, from 31% to 10% of the total protein. K converts much of it to true protein N, vital to animal feed.

they added 160 lbs (K_2O) potassium per acre, non-protein nitrogen tested only 10%. K had reduced the useless, potentially harmful non-protein N two-thirds—and in the process converted much of it to valuable true protein. Not a glamorous job. Nothing you can see. But very important to the animals.

In other tests, nitrogen increased PER TON VALUE of orchard-grass hay from $23.83 at 100 lbs N to $31.33 at 500 lbs N per acre. The testers applied 600 lbs K annually to help convert more of the increasing nitrogen into true protein N. They work together, nitrogen and potassium. That's why they must be kept in right balance or right proportion to each other. Increasing nitrogen rates increases potassium need.

We can go on with the ways potassium wins yields, reported from scientific trials and successful farms, showing. . . .

- **HOW** it gave a 3 for 1 dollar return above fertilizer cost on corn silage, an important feed crop.
- **HOW** net dollar return on four corn crops increased right up to 200 lbs (K_2O) per acre and then leveled.
- **HOW** scientists used 200 lbs (K_2O) per acre to raise two soybean crops some 10 bushels per acre over two years.
- **HOW** it increased southern seed cotton over four times (from 522 to 2,126 lbs per acre) when it was increased four times—from 25 to 100 lbs K_2O per acre.
- **HOW** it boosted lint cotton in the arid West from 642 to 1,013 lbs per acre when they added 400 lbs (K_2O) per acre.

Potassium's yield experiences are legion, but space asks us to move to other ways it influences crops.

> **"Potassium builds crop quality—fatter kernels in corn, less moisture in soybeans, more leaves in alfalfa, better taste, color, and firmness in such crops as peaches and tomatoes."**

WHEN STEPS TAKEN TO INCREASE a crop's yield also increase its quality, the bonus is big. Research has uncovered many ways potassium improves crop quality when in right balance with other plant nutrients. With deficient potassium, added potassium has shown us much:

IN CORN . . . potassium has increased number of kernels 28%, kernel weights 33%, total ear weight (grain and cob) 55%, while improving feed value of the grain. New high lysine corn, richer in body building protein than normal hybrids, is much higher in potassium. And in corn silage, K has increased energy production, doubled carotene (vitamin A builder) content for ripe ears on green stalks . . . reduced dry matter loss during ensiling process . . . and increased true protein and reduced non-protein nitrogen.

IN SOYBEANS . . . potassium has reduced the number of shrunken, moldy, discolored beans 34% . . . has boosted seed weight 29% and germination rate 11% . . . has reduced moisture buildup 46% . . . and has led to 14% less damaged seed.

IN ALFALFA . . . potassium has insured more frequent cuts by stimulating faster regrowth . . . has more than doubled the proportion of leaves to stems . . . and has almost doubled feeding value through more frequent cutting of rapid growing varieties. Regrowth spurted from 733 lbs without potassium to 1,285 lbs per acre in 18 days with 400 lbs K_2O per acre.

IN COTTON . . . potassium has produced 24% larger bolls, 6% greater mean strength, 18% more mature fiber, and nearly 29% more oil in the seed . . . while it was boosting yield 702 lbs MORE cotton per acre.

IN VEGETABLES . . . potassium has increased specific gravity and russeting in potatoes . . . reduced culls while improving inside color, taste, and size of tomatoes . . . and increased both the fresh weight of immature seeds and the tenderometer readings of peas. K has boosted the percentage of No. 1 grade potatoes, tomatoes, peppers, sweet corn, and lettuce enough for the farmer to feel it in his pocketbook.

IN FRUIT . . . potassium has improved firmness, keeping quality, tart taste, size, and color in peaches . . . insured good color and size in apples . . . increased both the juice and total acid in citrus, as well as fruit size . . . and boosted the sugar and acid content in grapes while preventing cluster-tip berries from drying out.

"Potassium speeds up crop maturity so that plants don't waste their energy on leaves, stalks and stems during vital grain developing weeks."

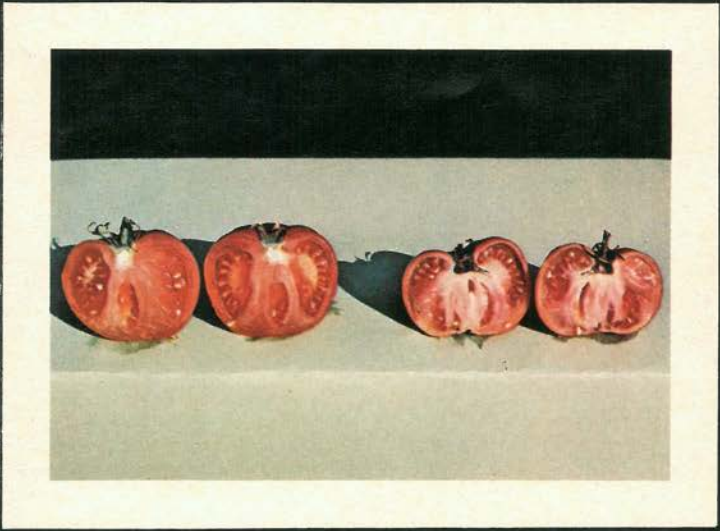
THIS IS A VITAL INFLUENCE . . . to get the leaf factory started and to keep it working . . . to help nitrogen and phosphorus start ear development early . . . and keep the process going as long as possible for maximum yield. K speeds up photosynthesis action and rushes growth materials to all vegetative parts.

Potassium helped corn reach silking stage 7 days earlier than the crop without potassium. Then, between silking and maturity, it kept the corn plants working longer to fill fatter ears. Plant breeders have searched a long time for hybrids with more time between silking and maturity . . . to boost yield potential. In another case, 200 lbs potassium brought 67% of the plants to silk on target date compared to only 14% of the corn not receiving potassium.

Potassium has also helped soybean plants mature earlier . . . especially on low fertility soils . . . so they could set more pods and shed their leaves. When K runs low, few pods are set . . . plants retain their leaves . . . yields run low . . . but, even worse, harvest can run late, right into bad weather. A classic example occurred where the soybeans enjoyed almost ideal weather until late drought. Then, in potash-deficient fields, late maturing soybeans would not mature . . . leaves did not shed . . . stems stayed green. Yet, fields with high potassium levels produced very good yields.

In fruit crops, scientists have found potassium helping trees hold the fruit until maturity. High potassium rates, for example, reduced grapefruit drop from 46 to 33%—a 13% saving.

To produce No. 1 grade vegetables, it pays to keep the K built up. . .



. . . because potassium builds profit-making quality. Potassium made the difference in the tomatoes above. High K tomato on left . . . low K tomato on right. Potassium improved color, stem ends, size, etc. Both direct and indirect effects of K hunger caused 26% culls at third and fourth pickings.

When soybeans mature too slowly, the soil may need more potassium. . .

. . . because low K can delay maturity in soybeans, silking time in corn. Soybean stems tend to stay green, leaves don't shed, less pods set, yields drop. Corn receiving plenty of N without K showed only 10% silking by August, but 90% silking when plenty of potassium was added (160-160-160). Success is in the balance.

"More plant diseases have been retarded by the use of potassium fertilizers than any other (nutrient), perhaps because potassium is so essential for catalyzing cell activities."

THE USDA YEARBOOK said this several years ago. Since then, many scientists have reported crop diseases aggravated by wrong nutrition. The problem is IMBALANCE, not absolute amounts of potassium or any other nutrients. When K helps a plant resist disease, it doesn't do it as a direct agent of control. It does it by strengthening the natural resistance mechanisms of the plant. Some scientists have compared it to a well balanced diet keeping humans vigorous and healthy enough to resist different viruses. Many tests in different areas have shown how potassium helps retard disease in crops:

- **Corn hit by southern corn leaf blight** a few years ago yielded 33 bushels more per acre on high-potassium soils—137 bushels on soil testing 421 lbs K compared to 104 bushels on soil testing 280 lbs K per acre. In a 3-year average before the blight hit, these trials yielded 171 bushels on the higher K soil, 149 bushels on the lower K soil.
- **Graywall in tomatoes declined sharply**—from 49% to a low 11%—when the potassium rate went from 50 lb to 400 lbs per acre.
- **More than 60% black spot showed up on potato** vines containing 2.4% K, but only 28% black spot from vines containing 10 to 12% K. In other tests, stem end rot showed up on 10% of the tubers with no K but on just 4% of the tubers with high K rates.
- **Much Holcus leaf spot showed up on corn** receiving 300 lbs nitrogen *even on high-K soil.* But when 100 lbs K was added with the nitrogen, disease signs declined and yields climbed 17 bushels per acre. Similar trends have occurred with bacterial leaf spot and chocolate spot—the higher the K the less the disease.
- **Rice suffered much less brown spot disease** when potassium level was right—spots usually small, disease staying close to the seat of infection. But on the potassium-hungry plants, the spots grew large, engulfing more of the plant. Potassium has also decreased stem rot and bacterial blight in rice. And blast disease, most universal rice problem, is often reported when high nitrogen rates do not get enough potassium.
- **Turf trials in many areas** have shown adequate potassium rates leading to less dollarspot disease in Tifway bermudagrass . . . 10 times less leafspot (from 148 down to only 14 spots per leaf) in Coastal bermudagrass . . . and 5 times less patch disease in turfgrass, especially when 145 lbs (K_2O) potassium was added to the nitrogen. Potassium does not cure disease, of course, but it helps harden the grass against invading organisms.
- **Corn hybrids can vary in the way** they will accept and use a plant nutrient. Hybrids that take up higher amounts of potassium in the leaf tissues have developed less severe leaf blight symptoms. The most severe blight has hit hybrids whose inbred parents were both low potassium accumulators. Potassium seems to help the plant realize its full genetic potential.

"I believe my corn stands better when I apply extra potassium."

MORE AND MORE FARMERS are saying this today . . . and for good reason. Research in many states has proved K builds strong stalks and more brace roots. When the corn plant does not get enough potassium, it ages too fast . . . cells die . . . tissues deteriorate, inviting stalk rot. This is very true when growers increase nitrogen and phosphorus rates and plant populations without increasing potassium in the balance.

Low-potassium corn in one state showed 80% lodging and 64 bushels per acre, while the high-potassium field showed only 5% lodging and 146 bushels per acre. In another state, lodging reached 70% without K and declined 26% with 80 lbs (K_2O) yearly. On another soil testing medium potassium, corn lodged 27% without K and just 8% when they added 60 lbs (K_2O) potassium per acre. And in another state, corn lodged 65% without K and only 16% when K joined the NPK team. It also brought along 31 EXTRA bushels in this case.

Potassium doesn't do this alone. It does it in harness with its brother nutrients. But one point is clear. Under today's high-nitrogen demands, potassium must be kept up to the right balance or you can look for lodging problems—like the corn that suffered almost 78% total lodging (49.5% root and 28.3% stalk) when it received 160 lbs nitrogen and 160 lbs phosphate (P_2O_5) without potassium. When they added 160 lbs potash (K_2O) to the fertilizer, the corn suffered only 10.3% total lodging (9.8% root and 0.5% stalk)—or 68% less lodging problems from potassium.

"Potassium must be some kind of anti-freeze. It sure did bring my alfalfa through that bitter cold spell last winter."

YOU HEAR THIS KIND of talk often today. Potassium is no miracle mineral, but research has shown it helps reduce winterkill in many crops—and has been doing it a long time. Nearly 70 years ago, a European scientist observed, "Potassium fertilizers have enabled lucerne and many other crops to more successfully withstand the rigors of winter." Today top growers ask their alfalfa to produce 6 to 10 tons and their wheat 60 to 100 bushels per acre. To do this, perennial forages and winter annuals must be fit for winter cold.

Winterkill is several things. Heaving—where freezing-thawing soils literally heave plants from the earth, breaking and exposing roots. **Suffocation—**where ice sheets can cause a fast-breathing plant to choke on the toxic products of its own breath when they can't get out. **Thirst—**where plants can't get enough to drink from frozen soil that acts like a dry soil. **Rupture—**where freezing plant cells burst, losing water and forming ice crystals that rupture cell walls.

Modern research has shown how potassium tends to fight these winterkill conditions: By lowering freezing point of cell sap . . . developing extensive root systems against heaving threat . . . and enlarging the root's "pipelines"

When a crop runs low in potassium, look for invading organisms. . .

. . . because low-K crops seem to have low resistance. Potassium builds healthier crops to fight invading organisms during growth and even in storage—like these peaches. Note what K meant to storage life after 14 days (right). Low K peaches (left) broke down faster because they breathe faster.

When corn lodges at stalk or root, the crop may have run short on potassium. . .

. . . because low-K corn ages too fast . . . cells die . . . tissues deteriorate, inviting stalk rot. Potassium builds strong stalks and more brace roots. Research all over the nation has shown potassium reducing down corn from 20 to 75% . . . while adding anywhere from 30 to 70 more bushels through better standing corn.

(xylem vessels connecting leaves and roots) so nutrients can flow more fully and evenly to all plant parts.

A classic example occurred with Tifgreen Bermuda grass. When it received plenty of nitrogen but no potassium, 50% winterkill occurred at 26°F. When plenty of potassium was added to the nitrogen, 50% winterkill did not occur until several degrees lower—at 18°F. The point? Potassium gave that grower an 8-degree cushion against winterkill, a lot of protection in dead of winter.

The same thing has happened to other crops. Northern vegetables got through 4° lower temperatures in early spring without frost damage when they received enough potassium. Peach trees subjected to −7.8° in Ontario showed 40% more fruit buds killed at low K levels than at high K levels. And 90% of a poorly fertilized alfalfa crop died during a severe winter, while only 20% of the well fertilized crop died out. Some now suggest frequently cut alfalfa might survive winter better if the plant contains 3 to 4% potassium rather than the traditional 2%.

Potassium gives grass crops fed high nitrogen rates a lot of help. This cannot be over-emphasized. Nitrogen is vital to best yields, but N gives fast, lush growth, soft and ripe for winterkill. Potassium helps harden this lush growth. A good example is Coastal Bermudagrass that received 400 lbs of nitrogen. Going from 0 to 200 lbs of potash (K_2O) saved 40% MORE of the stand—up to 75%. Potassium makes crops more stress-sure—that's for sure.

"Potassium must be a coolant of some kind. It sure did bring my soybeans through that bad dry spell last summer."

AGAIN, POTASSIUM IS no miracle mineral. But research has shown plants well fed with potassium actually use less water per bushel of grain or pound of dry matter they produce. Why? Because potassium prevents sluggish closing and opening of stomata, those tiny pores through which a plant breathes and can lose moisture. Scientists have recently learned that no other element can substitute for potassium in providing good stomata operation. They found guard cells of a smoothly operating stomate containing over two and a half times more potassium than a sluggish stomate.

In a sense, potassium helps "cut off the faucet" in the hot summer, slows down the plant's breathing rate to save energy, and gives the summer root system the same circulation help it gave winter crops. Potassium's role in building healthy, extensive root systems that can push four and more feet into the ground for hidden moisture cannot be over-emphasized. It also influences healthy leaf and stalk growth that covers the soil to reduce moisture evaporation, to slow impact of raindrops on the soil, and to decrease surface packing.

All this is vital in today's high-yield economy where top growers ask their corn to yield 150 bushels and their soybeans 50 to 60 bushels per acre. To do this, the crops must be fit for summer heat and dry spells. Summer wilt can strike an undernourished crop fast.

When scientists applied potassium to K-deficient crops, they found the potassium actually increasing the water in plants. A classic case occurred with sugar cane. Plants receiving high potassium rate (468 ppmK) kept moisture levels high in the top 13 leaves. But in plants receiving low potassium (39 ppmK), moisture dropped sharply below the 7th leaf, while leaves 12 and 13 lost turgidity and died from marginal drying. Leaves on the low-K plant were limp, their tips often frayed from blowing in the wind.

Another case occurred with soybeans. Dry weather is hard on soybeans. In one area one year, soybeans enjoyed almost ideal weather until a late drought hit. When the area agronomist checked the fields, he found many potassium-deficient crops. The farmers could not believe potassium was doing it. But scientific tests showed EACH problem field deficient in potassium. Yet, fields with good fertility levels produced very good yields. These farmers won't run short of potassium again.

Potassium helps make a crop more stress-sure—not only for too dry a soil, but also too wet or too cool. For example, on corn receiving low rainfall (less than 8 inches), potassium added 39 bushels to the yield—from 91 to 130 bushels per acre. On corn receiving heavy rainfall (nearly 26 inches), potassium added 48 bushels—from 92 to 140 bushels per acre.

Potassium also helps on cool soils—a big asset with early planting. Even on very high K soils (testing 940 lbs available K!), scientists used 25 lbs K in the cool soils of early planted rows to get 5.5 bushels MORE barley per acre. Research has shown low soil temperature reduces K uptake, making K fertilization a must for successful early planting.

There are many other cases of well balanced fertilizer programs (NPK) adding yields during seasons that received less than half normal rainfall—24 bushels more corn, 12 bushels more soybeans, 2.8 tons more alfalfa, 41 bushels more wheat. What about normal years? Well . . . we still have the farmer who uses 17 inches of water to grow 80 bushels of corn while his neighbor uses 17 inches to grow 140 bushels per acre. Someone is wasting moisture. Can adequate potassium stop that waste? Not alone—but in a well balanced fertility program, it can surely turn off the faucet.

"Unless my eyes are deceiving me, high potassium rates seem to toughen my turf . . . to take more traffic and weather."

THESE TURF GROWERS are not blind. Potassium IS making their turf stronger. It increases lignin content in the grass and often insures more water in the turf. This strengthens the blade and stiffens the foliage so it will return to upright position quicker than turf with low potassium rates. When scientists tested tensile strength of bluegrass, they found adequate potassium made the grass 20% stronger on a soil low in K.

Some scientists say potassium is vital for reducing high temperature injury to bluegrass turf. During hot weather, they found low-K turf wilting faster, but adequate K reduced water loss. Most lawn and turf growers think largely of nitrogen to keep summer grass green and growing. But for a fuller root system and a stronger plant in hot weather, tests showed a fertilizer high in potassium (sometimes higher than nitrogen in mid-summer) may be needed, especially on Bermuda greens. And where clippings are removed, potassium level drops even more rapidly—proved by poor putting greens in golf. It pays to be K-sure.

Crops resisting summer wilt best test higher in potassium than wilters. . .

. . . because potassium helps "cut off the faucet" in hot summer, slows the plant's breathing rate to save energy, and gives summer root system the same circulation help it gave winter crops. Healthy leaf and stalk growth covers soil to reduce moisture evaporation and slow raindrop "packing."

To help insure against winterkill, it pays to pour on the potassium . . .

. . . because K helps harden the fast, lush growth N gives forage crops. Low K can lose grass stands to winterkill, above. A balanced fertilizer program is vital . . . because many high-yield grass and grass-legume crops remove more K than N from the soil. Success is in the balance.

5—Do today's high-yield crops deplete our soils of life-giving potassium—and just how much?

IF WE OVERDRAW OUR CHECKING account in the bank, we hear about it—quickly! If we overdraw our potassium account in the soil, we hear about it—slowly! Usually too slowly to help this year's crop. Spring and fall weather can be "murder" some years, causing many fields to go unfertilized. They have to "borrow" nutrients from their own reserves. Then, if fall weather again holds farmers back, the soil can really go begging. Such fields cannot live long on their own reserves—not in these days of high-yield varieties bred to keep our food supply ahead of our population.

A grower producing 180 bushels of corn per acre will need more NPK than for 130 bushels crop. Why? Because a 180-bushel crop contains about 240 lbs N, 100 lbs P_2O_5 and 240 lbs K_2O, considerably more than in a 130 bushel crop. Other crops can be just as demanding in their high-yield habits. A 60-bushel soybean crop contains 336 lbs nitrogen, 65 lbs phosphate (P_2O_5), and 145 lbs potash (K_2O). And an 8-ton alfalfa crop contains 450 lbs nitrogen, 80 lbs phosphate (P_2O_5), and 480 lbs potash (K_2O).

We must keep in mind that in a forage crop the total amount is removed while in other crops only that in the grain or fruit is removed.

High yields are just one reason top farmers have become UPTAKE conscious. There are other reasons to be UPTAKE conscious:

- **Each soil area has just so much natural nutrition, sometimes not too available to the crop.**
- **Manure contains only the nutrition of a previous crop—to enrich one field only by robbing another field.**
- **Composting offers little to the modern farmer who already leaves residues from previous crops on his fields or works them into the soil.**
- **Too little or too much moisture and poor drainage . . . poor soil aeration and compaction . . . can all reduce root growth and nutrient uptake . . . requiring high potassium rates to face such stress periods.**
- **Crop variety can influence nutrient uptake . . . such as one corn hybrid absorbing more potassium than another in the same field . . . one alfalfa variety showing K hunger sooner than another.**

What is a good fertilizer program? Decide this way: (1) Set yield goals. (2) Know how much plant food THAT yield contains. (3) Determine the general soil fertility level. (4) Apply enough nutrients to meet crop needs at the yield level you can produce. Research has established uptake figures for most major crops. From these figures (on the opposite page), anyone can calculate what his current yields take up and what tomorrow's goals may absorb.

PLANT FOOD UTILIZATION

Lb/A	CORN 180 bu	CORN SILAGE 32 tons	COTTON 1500 lb (Lint)	WHEAT 80 bu	OATS 100 bu	BARLEY 100 bu	RICE 7000 lb	GRAIN SORGHUM 8000 lb	SUGAR BEETS 30 tons	SUGAR CANE 100 tons
N	240	240	180	186	115	150	112	250	255	360
P_2O_5	100	100	63	54	40	55	60	90	40	156
K_2O	240	300	126	162	145	150	168	200	550	610
Mg	50	50	35	24	20	17	14	44	80	100
S	30	30	30	20	20	20	12	38	45	86

Lb/A	TOBACCO Flue-Cured 3000 lb	TOBACCO Burley 4000 lb	SOYBEANS* 60 bu	PEANUTS* (Nuts) 4000 lb	COCONUTS 3600 Nuts	OIL PALM 13,382 lb	PINEAPPLE 35,700 lb	BANANA 1200 Plants	APPLES 600 Boxes	PEACHES 600 bu
N	126	240	336	240	75	615	153	400	100	95
P_2O_5	26	30	65	39	25	316	125	400	46	40
K_2O	257	264	145	185	120	481	596	1500	180	120
Mg	24	27	27	25	20	196	64	156	24	—
S	19	45	25	21	12	—	14	—	—	—

Lb/A	GRAPES 12 tons	ORANGES 600 Boxes	TOMATOES 40 tons	IRISH POTATOES 500 cwt.	CELERY 75 tons	LETTUCE 20 tons	SWEET POTATOES 400 bu	CABBAGE 35 tons	SNAP BEANS 4 tons	TABLE BEETS 25 tons
N	102	265	232	252	280	100	103	228	138	360
P_2O_5	35	55	87	114	165	44	40	63	32	43
K_2O	156	330	463	354	750	198	210	249	163	580
Mg	—	38	36	32	—	7	11	36	17	104
S	—	28	54	24	—	—	—	64	—	41

Lb/A	ALFALFA* 8 tons	CLOVER-* GRASS 6 tons	COASTAL BERMUDA 10 tons	ORCHARD GRASS 6 tons	TIMOTHY 4 tons	PANGOLA-GRASS 11.8 tons	BROME-GRASS 5 tons	SORGHUM-SUDAN 7.9 tons	BENTGRASS 2.5 tons	BERMUDA GRASS 4 tons
									TURF	
N	450	300	500	300	150	299	166	319	225	225
P_2O_5	80	90	140	100	55	108	66	122	80	40
K_2O	480	360	420	375	250	430	254	467	160	160
Mg	40	30	45	25	10	67	10	47	12	20
S	40	30	45	35	16	46	20	—	10	15

*LEGUMES CAN GET MOST OF THEIR NITROGEN FROM THE AIR

Good Acre Yields TAKE UP Much Plant Food

Potash Institute of North America
1649 Tullie Circle, N E Atlanta, Ga. 30329

THE TOP FARMER KNOWS how important it is for his soil to be able to supply all the plant food his crop needs—WHEN it needs it, WHERE it needs it—during the WHOLE season. Plant growth is a continuous process. And many a crop has started toward a great yield only to "run out of gas" or nutrition. Why? Because the grower did not fertilize enough to meet all nutrient stress periods. On the opposite page, you can pinpoint stress periods for three major crops:

LOOK AT THE CORN CROP . . . it uses half its potassium (53% or 126 lbs K_2O) during the first 50 days of growth and up to 84% (198 lbs K_2O) by silking time. Why? Because potassium is so vital for opening leaf pores (stomata) and transporting sugars to developing ears. Grain development pulls hardest on nitrogen and phosphate. Ear filling demands 57% (about 140 lbs) of the nitrogen and 70% (70 lbs P_2O_5) of the phosphate.

LOOK AT THE SOYBEAN CROP . . . Soybeans seem to absorb nutrients much like corn during early growth. But the peak demand for potassium (and other elements) comes during rapid vegetative growth just before pods form. Yet, look at the healthy demand for potassium and other elements **right up to maturity.** In fact, it looks like soybeans absorb about a third of their potassium during the last 30 days or so. No wonder many champion soybean yields are coming from well fertilized crops these days . . . they are pulling hard on those nutrients right up to harvest.

LOOK AT THE ALFALFA CROP . . . The most potassium went out with the first cut—harvested very early as the terminal buds were developing. This Rutgers University work showed the plants in the first cut contained 2.5% K, and they never dropped below 2.25% K over the last 3 cuts. Each succeeding harvest removed a few pounds less potassium (and other nutrients) because of less yield and percent K in the plant tissue. Yet, that 1.5 tons of hay from the FOURTH CUT means this soil was really built up (especially with potassium) to insure enough nutrients ALL season. Where no potassium was applied for 5 years in this trial, yields did not reach 4 tons and stands grew weak. Annual fertilizer applications (high in potassium) will maintain good yields and insure enough nutrients to winterize those alfalfa plants for the coming cold. (The full Rutgers report by Dr. Roy Flannery will be the cover feature in the next issue.)

These nutrient stress periods in corn, soybeans, and alfalfa tell us two things:

(1) The plant food needs of a given crop will never stand still, because farmers are always trying to improve their methods, to get more yield on each acre. And the more yield we can grow on a given acre the more plant food will be demanded.

(2) Higher yields and quality from more frequent forage cuttings put greater stress on the soil's nutrient reserves. This stress must be met or the harvests will have to be cut back.

IF YOU WOULD LIKE TO ORDER EXTRA COPIES OF THIS BOOKLET, USE THE QUICK COUPON ON THE BACK COVER. ALL ORDERS ARE PROMPTLY FILLED.

Crops Absorb Nutrients ALL Season

CORN — 180 BU/A

Plant Food	First 25 Days	Second 25 Days	Third 25 Days	Fourth 25 Days	Last 15 Days	TOTAL
N	19 lb	84 lb	75 lb	48 lb	14 lb	**240**
P_2O_5	4	27	36	25	8	**100**
K_2O	**22**	**104**	**72**	**36**	**6**	**240**
	PERCENT OF PLANT FOOD NEED TAKEN UP					
N	8%	35%	31%	20%	6%	**100**
P_2O_5	4	27	36	25	8	**100**
K_2O	**9**	**44**	**31**	**14**	**2**	**100**

SOYBEANS — 50 BU/A

Plant Food	At 40 Days	At 80 Days	At 100 Days	At 120 Days	TOTAL 140 Days
N	7.6 lb	125 lb	134 lb	196 lb	**257 lb**
P_2O_5	1.1	21	24	36	**48**
K_2O	**6.1**	**105**	**112**	**150**	**187**
	PERCENT OF PLANT FOOD NEED TAKEN UP				
N	2.9%	49%	52%	76%	**100**
P_2O_5	2.3	44	51	76	**100**
K_2O	**3.3**	**56**	**59**	**80**	**100**

From N.C. State University Data

ALFALFA — 8 TONS/A

Plant Food	1st Cut 2.35 Tons	2nd Cut 2.10 Tons	3rd Cut 2.03 Tons	4th Cut 1.52 Tons	TOTAL
N	136 lb	111 lb	93 lb	75 lb	**415**
P_2O_5	31	24	22	17	**94**
K_2O	**124**	**107**	**98**	**72**	**401**

From Rutgers University Data

6—How much potassium do our animals need and are they getting it in this high pressure age?

FOR ANIMALS . . . the traditional idea of "natural ingredients" supplying adequate potassium levels no longer holds true in many modern rations.

The potassium content of some typical feedstuffs shows why more and more growers are supplementing potassium in their finishing rations for beef:

K CONTENT OF FEED STUFFS

High K Sources	%K
Wheat bran	1.23
Linseed oil meal	1.38
Cottonseed meal	1.47
Cond. fish solubles	1.70
Soybean oil meal	2.00
Alfalfa meal	2.02
Cane molasses	2.60
Double Sulfate of potassium & magnesium	18.00
Potassium sulfate	41.00
Potassium chloride	50.00

Marginal K Sources	% K
Meat scraps	0.55
Hominy feed	0.61
Wheat germ meal	0.78
Wheat shorts	0.85

Low K Sources	%K
Urea	0.00
Corn gluten meal	0.02
Wood molasses	0.03
Oyster shell	0.09
Rice	0.15
Corn	0.29
Fish meal	0.29
Milo	0.35
Oats	0.37
Wheat	0.42
Barley	0.49

Two facts stand out in these potassium contents of feedstuffs: (1) Corn and other grains, corn gluten meal, and fishmeal don't insure much potassium for our animals, while soybean meal, cottonseed meal, good dehydrated alfalfa meal, and cane molasses give them abundant potassium. (2) When you reduce your soybean meal or partially replace it with urea, you pull down the potassium level of your diet significantly.

After recognizing potassium as a critical element, nutritionists are pinpointing dietary levels:

WITH SHEEP . . . researchers have gotten their best rate of gain, feed intake, dressing per cent, carcass gain and grade from 0.62% K in the ration, the highest they tried. Carcass weight rose more than 5 lbs. from 0.30% K to 0.62% K in the ration.

WITH BEEF CATTLE . . . they have found 0.8% potassium in the ration is a good level for growing and finishing steers and heifers. High-forage rations will meet this K level, but rarely high-grain rations. Grains too often contain less than 0.5% potassium—and the K level in high-concentrate or all-concentrate rations may run critically low, the National Research Council warns. If the cattle chew wood on the pens and barns, check for low-potassium rations.

WITH DAIRY CATTLE . . . heifers, dry cows, and milk cows may need up to 0.8% potassium in their rations. Some believe a peak milk cow may need a ration containing at least 1.0% potassium. Cow's milk contains much more potassium than any other mineral, including calcium and phosphorus. Few realize how much potassium a good milk cow can excrete in her daily milk—and with a constant potassium concentration. Her ration must return this potassium. But our modern systems usually feed the best milk animals a higher concentrate ration (with low potassium).

Potassium deficiency could become a real problem to our dairy herds. In tests, potassium-deficient animals have consumed 34% less feed, produced 25% less milk daily, licked the floor and the hair of their stallmates, and lost their glossy coat.

WITH POULTRY . . . today's high-protein, high-energy diets for fast growth may require 0.5 to 0.7% potassium in the ration. Tests show interesting results: (1) A huge 78.7% death rate at 0.1% dietary potassium, but no deaths at 0.6% potassium. (2) Weight gain between 2nd and 4th week 84 gm at 0.1% dietary potassium, but 350 gm at 0.5% potassium. (3) As both the protein level and energy content of the diet increase, potassium need increases, though not in proportion to the protein. (4) Less bone ash and skeletal muscle protein in potash-deficient chicks. (5) Day-old chicks fed potassium deficient diets fall behind potassium-fed chicks in body weight and feed consumption within 24 hours, and further behind with time.

WITH TURKEYS . . . young poults need 0.6% potassium for early growth . . . around 0.3% potassium for 50% survival. Best weight gain, feed efficiency, and survival rate came from rations containing almost 0.6% (0.58%) potassium.

WITH SWINE . . . pigs need more than 0.6 to 0.8% potassium, the levels found in some unsupplemented diets. They may need as much as 1.0-1.2% potassium for best weight gains and feed efficiency. Protein and potassium seem to work as a team. With each increment of added protein through an 18% protein level, added potassium helped boost weight and efficiency until the ration reached between 1.17% and 1.39% potassium. If they grow stiff and irritable, check that potassium level.

Crops, like animals, must be fed before they can pass on the nutrition to our livestock. Forage crops have long proved this point. When grown on low fertility soils, their potassium content may test one-third to barely half the potassium in a crop grown on well fertilized soil. And the animal will often tell you the difference—in less health, less meat, less milk.

SEND US THIS POTASSIUM BOOKLET

	Quantity
Single copies, 25¢ ea.	________
2-99 copies, 20¢ ea.	________
100 or more copies, 15¢ ea.	________

NAME________________________

ADDRESS________________________

CITY________________________

STATE__________ ZIP__________

ORGANIZATION________________________

Total payment enclosed $________
(no shipping charge)

Bill us ☐
(shipping charges added on invoice)

ORDER EXTRA COPIES OF THIS ISSUE ON THIS COUPON. . . .

EXTRA COPIES OF THIS ISSUE AVAILABLE. . .

. . . TO DISTRIBUTE at conventions . . . in dinner meetings . . . at farm and field workshops . . . in direct mail . . . at technical conferences . . . in classroom work.

ORDER ON CONVENIENT CUTOUT COUPON ABOVE

Better Crops
WITH PLANT FOOD

Controlled circulation postage paid at Washington, D. C.

Potash Institute of North America
1649 Tullie Circle, N.E., Atlanta, Ga. 30329