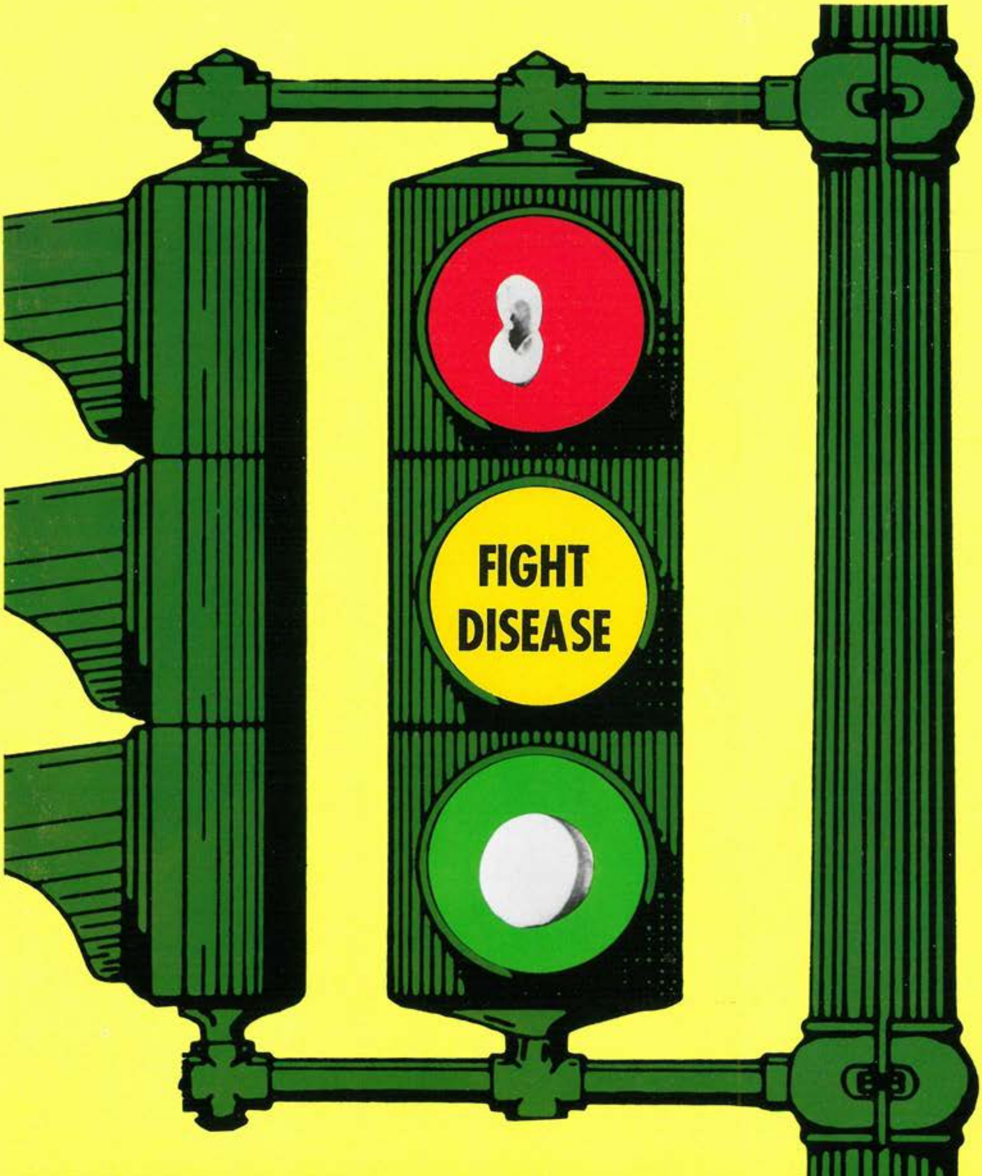
Better Crops

WITH PLANT FOOD

AUTUMN 1966 25 CENTS



IS YOUR CROP GO?

ON THE COVER—is your crop STOP or GO because of disease? Modern research is pointing toward adequate plant nutrition as a big weapon in fighting disease.

Did disease stop the corn on the left above? The deteriorating corn stalk, shown by cross section, shows something wrong! Whether it's a physiological breakdown brought on by environmental conditions or attack by a specific disease, the results can be the same: less crop, less profit.

In this case, the cross section of corn stalk (left above) came from corn that did not get enough potassium in its NPK diet. The stalk died too early, allowing secondary rot organisms to enter and weaken it. Excess lodging occurred.

The other cross section (right) came from strong, healthy corn. Adequate NPK diet kept the stalk green and active for a longer time. Lodging was minor, thanks to a balanced diet.

All this stands to reason. People give in to viruses, to all kinds of bugs when they don't keep themselves built up. Why not plants?

In this special issue, nationally known authorities look at the role of plant nutrients in building disease resistance. Special issue chairmen were R. E. Wagner, Eastern Director, and W. K. Griffith, Assistant to the President of the American Potash Institute.

Better Crops WITH PLANT FOOD

The Whole Truth—Not Selected Truth

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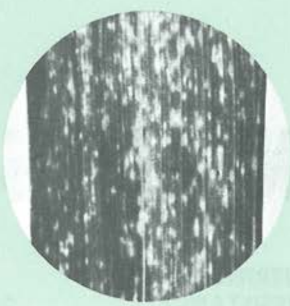

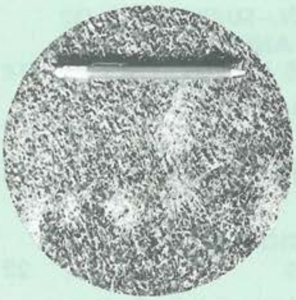

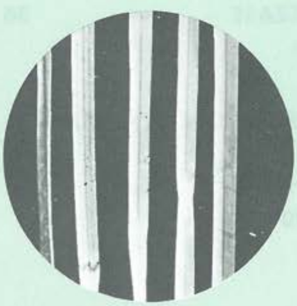

PLANT NUTRIENTS and DISEASE RESISTANCE

ANY RELATIONSHIP?

PLANT diseases cost the American farmer an estimated $3 billion a year and the farmer does not always recognize the full extent of damage.

Much of this loss can be prevented. In fact, disease is one limiting factor man can control to a great extent. But too often he fails to apply the controls needed for top-profit crops, turf, or ornamental plants.

DISEASES IN ACTION

There are two major groups of plant diseases: **non-parasitic and parasitic.**

Non-parasitic diseases result from poor inherent qualities of the plant or unfavorable environmental factors, such as soil, air, moisture, nutrients, mechanical damage, etc. Severity and type of injury vary with the plant, its stage of maturity when

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"MANY WORKERS REPORT NUTRIENTS HELP REDUCE DISEASES—TOO MANY TO DISCOUNT THE RELATIONSHIP."

the disturbance occurs, and the part of the plant involved.

Parasitic diseases are caused by pathogens or parasites which live at the expense of their host—fungi and bacteria, for example.

Parasitic infection can be divided into two stages: **(1) the entry of the organism into the plant, (2) the the spread of the infection once the disease organism is there.**

It can enter at many points: through weak or injured roots, through mechanical or insect-injured tissue, through thin cell walls or epidermal layers, dead tissue, stomata, etc.

Once inside, the infection can spread more rapidly (1) WHEN the supply of chemical compounds in the cells is unbalanced, (2) WHEN the flow (translocation) of food stuffs to or from the roots is reduced, (3) WHEN the plant is unable to photosynthesize or to form new tissue.

WHAT ABOUT NUTRIENTS

Plant nutrients can help plants resist or withstand attacks of both parasitic and non-parasitic diseases.

In many cases, the relationship concerns an unbalanced supply of nutrients rather than the direct effect of any one element. The vigorous root and top growth of plants supplied with adequate and balanced nutrients can help plants resist attacks of organisms or to outgrow the effects of disease invasion.

We know nitrogen is needed to form protein, the living protoplasm. It stimulates vigorous and rapid growth. But when large amounts of nitrogen are used with an inadequate supply of some other nutrient, the plant usually develops soft, lush growth with weakened cell walls—**a plant more susceptible to disease attack.**

Phosphorus is important for energy and early vigor. Sulfur is known to be essential for forming proteins. Calcium, magnesium, iron, manganese, and the other essential elements have important roles.

All are necessary in producing the normal chemical compounds and in maintaining their balance in the plant. Some are prominently associated with disease reaction of plants.

ROLE OF POTASSIUM

Just in the past 10 years, over 50 articles dealing with the relationship of potassium to disease resistance have appeared in *Potash Abstracts*.

Dr. George L. McNew in the USDA Year Book of Agriculture on Plant Diseases states, **"More plant diseases have been retarded by the use of potash fertilizers than any other substance, perhaps because potassium is so essential for catalyzing cell activities."**

Under most circumstances, potassium deficiency implies many problems for the plant:

- **An excess of non-protein nitrogen.**
- **Thinner cell walls and epidermal tissues.**
- **Reduced production of amino acids due to suppressed nitrate production.**
- **Accumulation of carbohydrates that cannot be synthesized into proteins.**
- **Failure to produce new cells for lack of amino acids essential for protoplasm.**
- **Slower growth of meristematic tissue that permits replacement of diseased tissues.**

These conditions may enable plant parasites to penetrate the epidermis to increase their metabolism and growth in plant tissues, or to destroy the entire plant because it cannot develop new tissue or replace that lost to pathogens.

Potassium fertilization has reduced the severity of leaf blight and stalk rot in corn, black spot and stem end rot in potatoes, Fusarium wilt and damping off of cotton, leafspot and dollarspot in grasses, wildfire in tobacco, stem rot in tomatoes, black leaf in grapes, and mildew in many crops.

THEORIES BEHIND K ACTION

The nature of this action or the mechanism involved are not well known. The ability of potassium or any nutrient to act as a systemic fungicide is most unlikely. But several theories suggest the role potassium plays in reducing the incidence of certain diseases. The following are listed in no special order of importance. One or all could be involved in the many diseases where the relationship exists.

1. Stalks and stems. Potassium is known to affect stalk and stem strength. Corn work has shown parenchyma cells and stalk tissue breaking down under medium or low potassium conditions. Secondary infection by disease organisms then appears more rapidly.

2. Cereals. Those high in potassium have thicker cuticles or epidermal layers that may be a factor in reducing mildew and other disease infection.

3. Corn roots. Iron accumulates in the nodes of potassium-deficient corn, interfering with translocation of nutrients to and from the root. Roots then weaken and become more susceptible to disease organisms in the soil.

4. Alfalfa. Potassium has given more, larger, and more evenly distributed xylem vessels. This gives better flow and distribution of metabolites in the alfalfa plant, enabling it to withstand harmful forces better. The larger vessels are less subject to clogging from vascular diseases.

5. Sugar and protein. Potassium is known to affect both the sugar or carbohydrate and protein levels in plants. Under potassium deficiency, especially coupled with high nitrogen, compounds become unbalanced in the plant. Non-protein nitrogen compounds form, starch and cellulose formation is reduced, and unused carbohydrate compounds accumulate. High concentrations of sugars and nitrates in K-deficient plants make more favorable media for the development of disease organisms.

6. Moisture. Potassium is known to affect the moisture relationship within a plant. Cells of potassium-adequate plants are more turgid, giving less suitable environment for invading disease organisms. Some disease organisms, as that causing wildfire in tobacco, need free moisture for invasion. After storms, leaves of potassium-deficient plants are more readily water soaked than potassium-adequate plants. Such water-soaked leaves give more suitable entry.

7. Stomata. Potassium affects the number, size, and action of stomata. Stomata are important in transpiration and exchange of gases in and out of the plant. They are thought to be one point of entry for disease organisms. With adequate potassium, the stomata functions normally to help the plant resist disease invasion. Stomata close very sluggishly when potassium is deficient.

8. Root Crops. Blackening of potatoes or other root crops shows a non-parasitic disease. This is associated with the production of a black pigment melanine through enzymatic oxidation of the amino acid tyrosine. High nitrogen and low potassium increase tyrosine. But adequate potassium reduces the amount of tyrosine.

9. Leaf Tissue. Extreme potassium deficiency causes dead tissue to form on the leaf. These symptoms are associated with some non-parasitic diseases, such as leaf scorch or leaf burn. Some parasitic fungi enter by dead tissue. Many weak parasites gain entry to plants only as growth is slowed and senescence begins. Adequate potassium helps maintain growth and delay senescence, reducing and delaying infection by these organisms.

10. Enzymes. Potassium is known to help activate over 25 enzymes. Many of the resulting compounds formed are key metabolites to the normal functioning of the chemical system in plants. Upsetting the normal routes of a plant's chemistry, by any means, renders the plant more susceptible to diseases.

ANOTHER THEORY

Dr. Mark Stahmann, a University of Wisconsin biochemist, has given a theory of how plant chemistry could be related to disease resistance. He feels the invasion of a disease organism sets up a chemical battle within a plant. The invader, usually a fungus, secretes enzymes outside of the cell that break down plant pectin and protein. The products of this breakdown or hydrolysis are water, sugars, and amino acids. The invading parasite feeds on these products, and the softening of the tissue gives it an easy pathway to penetrate deeper into the plant. The secretion of these enzymes causes the plant to set up a counterattack by secreting oxidase enzymes which form phenols or quinones. These chemicals combine with protein and neutralize the enzymes of the invader.

Potassium is known to be active in some oxidase enzyme systems. Could the action of K be involved in the theory suggested by Dr. Stahmann?

SPECIFIC WORK NEEDED

Many workers report nutrients have played a role in reducing diseases—too many to discount this relationship. This issue brings together the available information on selected crops.

Obviously lacking is specific work on the mechanism of action of nutrients on disease resistance. More effort in this direction could unlock secrets that would enable nutrients to play an even bigger role in disease control. **THE END**


GIBBERELLA

Plant Nutrients on STALK ROT AND LODGING

BY A. L. HOOKER
UNIVERSITY OF ILLINOIS

FARMERS seek high corn yields —the highest ever, putting more stress on the corn plant. This stress can lead to such troubles as stalk rots and lodging.

CAUSES OF STALK ROTS AND LODGING

Fungus infections cause stalk rots. Fungi of the genera *Diplodia* and *Gibberella* are most important, but other fungi and some bacteria can also infect stalks.

These microorganisms are present in all corn fields. They usually enter the plant through the root system and spread into the stalk. They are primarily cortical-invading organisms.

Infection occurs from pollination to harvest. Diseased plants die suddenly. This is often confused with maturity. Premature plant death lowers yield and grain quality. Weak, rotted stalks frequently lodge. Down stalks are difficult to harvest, and ears contacting moist soil are soon rotted by fungi. Profits may drop 25%.

Plants with weak roots may lodge during wind and rain storms. In root lodging, stalks need not be broken. Weak stalks can also break without the aid of rot fungi.

AGING TISSUE CANNOT RESIST ROT FUNGI

Stalk rots do not occur in actively growing corn plants. During ear formation, sugars are translocated from the stalk to the grain. Then stalk and root tissue begin to age.

There is a direct association between rate of tissue aging and susceptibility to rot fungi. Stalk pith tissue ages first in the center of the internode and last near the rind and node—first above the ear and gradually down to the base of the plant. When vegetative growth ceases, root and stalk rotting fungi move into the plant. Damage is greatest when this aging occurs early.

We can predict late season stalk rot and lodging by splitting stalks with a knife after silking. Plants with much white, fluffy, dry pith tissue are most likely to become diseased and lodge later on. Harvest early.

Resistant plants have light green, heavy, wet pith tissue in the lower stalk. With such plants you can de-

Diplodia Stalk Rot: "Observations and a few experiments have shown that more stalk rot occurs where soils are excessively high in nitrogen and low in potassium than where fertility is ample and balanced." U.S.D.A. Handbook 199

DIPLODIA

lay harvest, because late season lodging is less likely.

Resistant hybrids can resist stress without aging as quickly as susceptible hybrids—and their cells can apparently produce toxic chemicals when invaded by rot fungi. These chemicals limit disease spread. Aging or dead cells do not react in this manner.

HIGH SOIL FERTILITY PLUS MORE STALK ROT

High soil fertility favors stalk rots. The famed Morrow Plots at the University of Illinois, growing corn continuously since 1876, show this.

In a recent 5-year period, 38% of the stalks receiving moderate manure, lime, and fertilizer were rotted at harvest—only 15% in unfertilized plots! And year to year stalk rot ran three times greater in fertilized than in unfertilized plots.

On nearby high fertility plots, growing a resistant hybrid, the differences were even greater in 1965. Premature dying and sagging of ears on plants started near the end of August in heavily fertilized plots. By harvest stalk rot was over 12 times greater in high fertility plots than in the lime-phosphate only plots.

Higher yields carry more stalk rots. When plants are killed by disease before full maturity, the crop does not receive full value from fertilizer. Each diseased plant loses about 16% of its yield—but the full loss depends on stage of plant development when infection occurs.

FERTILITY IMBALANCE COMPOUNDS PROBLEM

Stalk rot and lodging is usually more severe when soil potassium content is medium to low in relation to nitrogen and phosphorus. In Illinois, the same hybrid grown with 80 pounds each of N, P_2O_5, and K_2O suffered only 17% stalk rot while plots with the same amount of N and P_2O_5 but no K showed 49% stalk rot. Similar trends have been found in New York, Minnesota, Wisconsin, Ohio, Texas, Washington, Tennessee, Iowa, Pennsylvania, North Carolina, and elsewhere.

Adequate nitrogen or nitrogen plus phosphorus increases the potassium requirement of the growing plant. When the soil cannot supply

TENNESSEE

Treatment			Dead stalks				Lodged plants	
N lb/A	P lb/A	K* lb/A	1957 %	1958 %	1959 %	1960 %	1959 %	1960 %
60	35	0	56	49	78	51	22	19
120	35	0	43	60	79	56	25	25
60	35	42	35	59	58	19	5	2
120	35	42	38	52	55	34	6	7
60	35	83	25	42	43	23	2	2
120	35	83	30	55	41	23	2	3
60	35	166	20	49	33	18	2	3
120	35	166	23	44	35	28	1	2

*For the four K levels, the K soil test readings were very low, low, medium, and high.

STALK LODGING
(By Corn Running Short of Potassium)

the plant with adequate potassium, this nutrient imbalance disturbs carbohydrate and protein metabolism and speeds up tissue aging and breakdown in the lower stalk and roots. This causes greater susceptibility to disease and lodging. **Potassium helps a genetically resistant plant maintain its natural resistance until late in the season. Adequate potassium also helps insure well developed root systems, plants less susceptible to root lodging.**

Most tests indicate that adding potassium to soils low in this nutrient improves standability and reduces stalk rot. But we do not know if a particular balance of nutrients will reduce stalk rot and lodging at very high fertility levels.

Fertilizer balance hastens maturity of most hybrids. Hybrids exhibiting low amounts of stalk rot under balanced nutrients tend to resist rot fungi rather than escape disease because of late maturity. Early maturity is important in northern states where early frosts and late harvests are constant hazards to corn production.

When needed, liming has reduced lodging but not stalk rot. Under certain conditions, phosphate may be an important factor in reducing lodging, but under other conditions no effect is apparent. Increased nitrogen frequently increases disease but in a Washington test, where disease was not a factor, lodging was not increased.

The effects of unbalanced soil fertility may be more pronounced with a stalk rot resistant than with a susceptible hybrid. A susceptible hybrid may rot severely even with adequate potassium in the soil.

In an Illinois study, two hybrids lodged badly in a potassium-deficient soil. Adding potassium fertilizer greatly improved standability of one hybrid but not the other. Were genetic controls a factor? Research will tell.

Increasing plant population with a given hybrid usually causes greater stalk rot and stalk lodging. For example, 62% of the plants rotted in plots with 24,000 plants per acre while only 25% of the same hybrid

WISCONSIN

Treatment N lb/A	P lb/A	K lb/A	Root and stalk lodging %
0	0	0	2
160	0	0	38
160	0	133	3
160	70	0	78
160	70	133	11

Soil test medium in P and K.

ILLINOIS

Plowdown N lb/A	P_2O_5 lb/A	K_2O lb/A	Rot Damaged stalks %	Corn Yield bu/A
0	0	0	16	80
80	0	0	40	84
0	80	0	21	84
0	0	80	17	88
0	80	80	13	85
80	80	0	49	76
80	80	80	17	110

Soil test medium in P & K.

ROOT LODGING
(By Corn Running Short of Potassium)

rotted in adjacent plots with 16,000 plants per acre at the same fertility.

In fields with 20,000 to 28,000 plants per acre, potassium rates may need to be raised 10 to 25% above rates considered adequate for lower plant populations, these 1965 Illinois tests indicate. **Why? Because extra potassium is needed to compensate for root systems of adjacent plants overlapping and feed in zones already depleted of potassium and other nonmobile nutrients.**

This adjustment in potassium rate, however, has not been tested under field conditions.

Stalk rot and lodging severity varies from season to season and from field to field. In certain soils and seasons, potassium may reduce stalk rot and lodging very little, if any. Severe stalk rot damage has occurred with a particular hybrid even with plenty of potassium. When conditions are most favorable for stalk rot and lodging, adequate potassium in the soil is not a sufficient control alone—but teamed up with other practices it helps cut losses.

Such factors as corn rootworm, corn borer, leaf diseases, previous crop, cultivation injury, moisture stress, wind and rain storms, and others also affect the incidence and severity of stalk rots and lodging.

IN SUMMARY

Detecting or eliminating the cause of stalk rot or lodging is often impossible. Many combinations of factors enter the problem. All answers are not now available.

More genetic resistance is needed —and breeders believe better resistance can be achieved. More facts are needed about the effect of fertility balance at very high fertility levels. And genetic control of nutrient uptake and movement in the plant needs further study.

But farmers can reduce losses by using a high-yielding hybrid that stands well under high fertility and plant population levels.

THE END

PLANT NUTRIENTS HELP CONTROL TURFGRASS DISEASE

BY ROY L. GOSS AND CHARLES J. GOULD
WASHINGTON STATE UNIVERSITY

VARIOUS plant nutrient levels influence three important turf-grass diseases in the Pacific Northwest:

1—*Fusarium* patch caused by the fungus *Fusarium nivale*.
2—Red thread caused by the fungus *Corticium fuciforme*.
3—*Ophiobolus* patch caused by *Ophiobulus graminis* var. *avenae*.

We have studied these diseases carefully at the Western Washington Research and Extension Center at Puyallup, Washington.

In the past, fungicidal controls have been used on the first two, and the third one only recently showed up in the Pacific Northwest. But in recent years, more and more tests have shown how strongly fertilization affects these diseases. Let's look at each one for its own traits and reactions to fertilization.

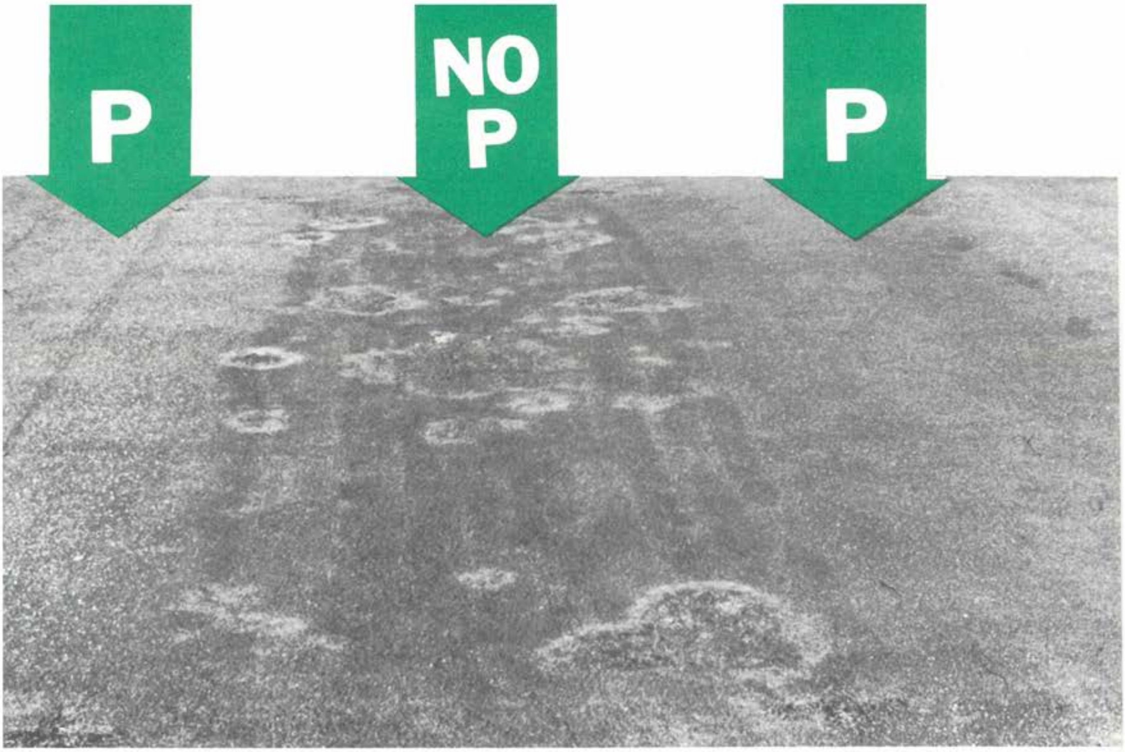
FUSARIUM PATCH DISEASE

This disease is primarily affected by nitrogen levels, extensive tests have shown. The higher the nitrogen level, within limits of our research, the greater the infection by *Fusarium* patch.

Our experiments have ranged from 20 lbs. of available nitrogen per 1000 sq. ft. per season down to 0 levels in check plots. The *Fusarium* patch fungus makes its greatest attack during the cool, moist fall and, again, in similar periods of early spring.

The lush, tender condition of heavily fertilized turfgrasses have been found more susceptible to the fungus than the more hardened and slower-growing grasses with less nitrogen.

Tests have also shown that the type of nitrogen plays an important role in the severity of disease attack. Plots receiving ammonium sulfate



Patch Disease (Ophiobolus) takes over part of this putting green—the part receiving no phosphorus since 1959. Phosphorus granules show up on both sides of the infected area.

had much less disease than those receiving urea. The exact cause has not been determined. But the experiment was repeated many times with the same results.

What About Phosphorus and Potassium . . .

The effects of phosphorus and potassium are less dramatic than that of nitrogen, but adequate levels contribute to disease resistance. A "balanced" fertilizer appears best.

. . . and Sulphur?

Preliminary tests have shown sulphur applications up to 1½ pounds elemental sulphur per 1000 sq. ft. significantly reducing the amount of *Fusarium* patch disease.

In one experiment, over 7 times the number of diseased spots was observed in plots not receiving sulphur. This response was observed regardless of nitrogen level.

RED THREAD DISEASE

The Red thread fungus causes a scorched look on fine-leaved fescues during any time of the year, on bentgrasses and annual bluegrass during slow-growing periods. The fungus causes part of the grass blades to die, giving a scorched look.

This disease is most noticeable on fescues during late summer and early fall, when plant nutrients (particularly nitrogen) are at lowest soil level for the season. After fertilizing his lawn early in the year, the average homeowner either cannot afford to or does not apply fertilizer during the summer or fall.

Cooperative nutritional and fungicidal experiments at our Research and Extension Center have shown top nitrogen levels will do more to control this disease during active growing season than any other single factor.

Nitrogen levels of approximately

TABLE 1. MEAN SOIL TEST VALUES AT 3 NITROGEN, 2 PHOSPHORUS, AND 3 POTASSIUM TREATMENTS FOR 1959 THROUGH 1963.

	AVERAGE SOIL LEVELS IN LBS/ACRE							
	Phosphorus			Potassium			Soil	
Nitrogen Lbs/A Applied	Initial 1959	No P Applied 1963	P Applied 1963	Initial 1959	No K Applied 1963	K Applied 1963	pH Levels 1959	1963
870	15	9	15	462	167	370	5.8	4.1
522	15	10	16	497	179	309	5.8	4.9
261	18	10	16	500	219	354	5.7	5.3

6 lbs. per 1000 sq. ft. applied uniformly over the growing season will maintain lawn-type turf in a beautiful, healthy growing condition. As long as the turf is actively growing, the leaves, even though partially infected, are clipped and the characteristic scorching appearance does not have an opportunity to develop.

During middle to late fall, Red thread disease appears more striking as growth rate declines. Here the fungus can completely develop and even produce the red threads for which it is named. At this season, fertilization is not recommended, so we must revert to fungicides, particularly the cadmium compounds, to control the disease.

What About Phosphorus and Potassium?

Here, as with *Fusarium* patch, less effect has been observed from phosphorus and potassium than from nitrogen applications. But if either phosphorus or potassium becomes limited enough to restrict growth rate, then either one could conceivably become as important as nitrogen.

Here, again, a balanced fertilizer program provides the best all-around results.

OPHIOBOLUS PATCH DISEASE

This disease is very interesting in its reaction to fertility levels.

On soils initially fumigated with methyl bromide, the disease developed vigorously in research plots during initial establishment of bent. The most disease occurred in all plots receiving highest nitrogen levels during the first year.

But as the grass grew older in the continuing experiment, the pattern of infection changed. By 1964, three years after the disease was first identified, the most severe infection occurred in plots receiving nitrogen only.

Table 1 shows both the initial fertility levels of the soil and also the levels at the end of 1963. The treatments in pounds per acre of nutrients per year were 870, 522, and 261 lbs. of nitrogen, respectively; 0 and 77 lbs. of P; and 0, 145, and 290 lbs. of K per acre applied to the plots at intervals throughout the season.

At the start of the experiment, note how the lowest phosphorus levels were 15 lbs. per acre, considered high enough for good turfgrass production in western Washington. For potassium, all but one level ran nearly 500 lbs. per acre at the start.

Four years later some of the phosphorus levels had dropped to 9 lbs. per acre while other plots actually increased from phosphorus applications. Many soil test results have indicated even 9 lbs. of phosphorus is not a limiting factor in turfgrass growth and quality.

Some of the plots not receiving any potassium had dwindled from nearly 500 lbs. to 149 lbs. per acre.

In comparing 1959 with 1963 pH levels, note how the lowest pH levels occurred at the highest nitrogen treatment—870 lbs. per acre. Each lower nitrogen rate increased pH level.

When these various fertility aspects were compared to the development of the *Ophiobolus* patch disease, some interesting results were observed.

What About Phosphorus . . .

The number of diseased spots tabulated in 1961 showed nearly as many spots in phosphorus plots as in no-phosphorus plots. But by 1964 a great difference showed up.

Plots receiving 77 lbs. P per acre showed only 15% as much infection as no-P plots at all levels of nitrogen and potassium—that is, no-P turf suffered almost 7 times more disease than P plots.

These findings closely agree with earlier investigators of the similar disease (take-all) in wheat. They found heavy applications of phosphatic fertilizers reducing attacks.

Figure 1 shows phosphorus at work on *Ophiobolus* patch disease.

What About Potassium . . .

Potassium also suppressed *Ophiobolus* patch disease—even from the early stages of the experiment, regardless of nitrogen and phosphorus levels.

At all nitrogen levels in 1964, the no-K and no-P turf suffered 5 times more disease than turf receiving 145 lbs. K and no P. The disease decreased as K increased at both P levels.

NUTRITION DOES PLAY A ROLE

These experiments show that nutrition does play an important role in disease development on turfgrasses.

Nitrogen is the most important factor—but balanced supplies of P and K must be present for suitable disease resistance.

Additional research is needed to consider how the various sources and levels of phosphorus, potassium, and pH interact on various pathogens.

THE END

FROM PAGE 40

effective to develop an artificial epiphytotic for blight and then select plants for development of disease resistant lines than to measure leaf potassium. **However, further research on the suggested relationship of potassium and disease resistance may be of value to pathologists and plant breeders.**

These facts also emphasize the need for caution in interpreting nutrient needs of corn from tissue analyses. Hybrid differences added to weather, soil, and other factors which are not constant will make such interpretations even more difficult. **THE END**

POTASSIUM

SUPPRESSOR OF DISEASES AND OTHER DISORDERS IN POTATOES

BY R. A. STRUCHTEMEYER
HEAD
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UNIVERSITY OF MAINE

POTATOES, like any other living organism, must be properly fed if they are to grow strong and healthy.

Many people have experimented with the problem of nutrition and disease susceptibility over the years. Nutrient elements have been used singly and in various combinations in studying this relationship. Many people have shown a relationship between nutrition and the disease susceptibility of potatoes. But even though positive relationships have been discovered, no one seems to have developed the area intensively and established the mechanisms involved.

When one limits the reference to a single element, such as potassium, the interactions between other elements cannot be ignored. With this being the case, the various findings cited in this study assume that where positive data were obtained with potassium the other elements were not interfering.

For many years plant physiologists have studied the role of potassium in plant nutrition. Research has led to the conclusion that **potassium acts as a counter balance to nitrogen and plays a role in "hardening" plants.** This hardening effect could be very significant in making potato plants more resistant to disease attacks.

REDUCES BLACK SPOT

Several people have studied the relationship of potassium fertilization to the occurrence of black spot in potatoes. Lorenz et al. (1957) working in California found that the **application of potassium fertilizer significantly reduced the occurrence of black spot in potatoes.**

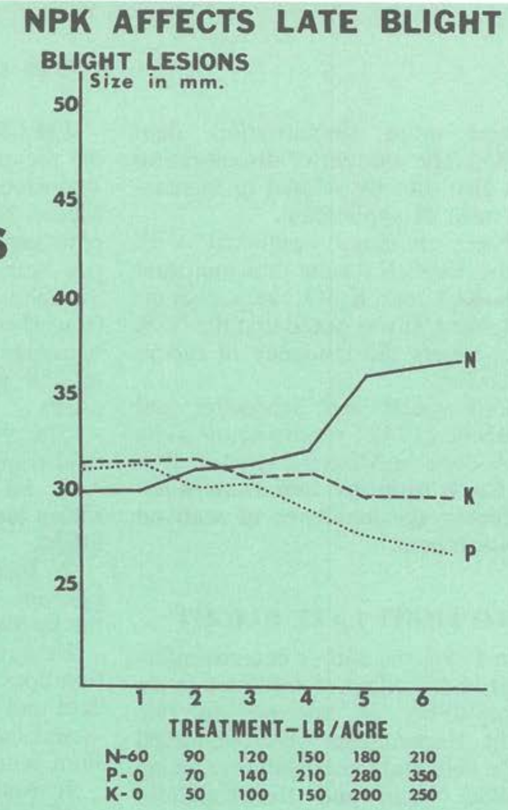
In one study where potato vines contained 2.4 percent potassium (K), 61.6 percent of the tubers showed black spot. But when potassium fertilizer was added and the vines contained 10 to 12 percent potassium (K), only 28.4 percent of the tubers had black spot.

In another report, Lorenz (1958) announced the possibility of controlling a type of physiological leaf roll and black spot or stem end bruising with the potash application. These trials were in Kern County, California.

Van Middelem et al. (1953) working with Green Mountain pota-

Phosphorus and Potassium UP

Blight DOWN



toes on Long Island concluded that **potassium through its effect on soluble nitrogenous fractions of the tubers may profoundly affect black spot incidence in susceptible potato tubers.**

Collin (1962) also working in New York reported that the ratio of **top K content: stem-end K** was proportional to susceptibility to black spot. In other words, adequate plant K meant less susceptibility, inadequate plant K meant more susceptibility.

Results from an African study conducted and reported by Brewer (1962) on potato stem end rot caused by Fusarium spp. proved that **nutrition of the host plant affects the incidence of the disease.** The results showed a potash main effect that was highly significant—the 240 pound per morgen K_2O level produced 4 percent diseased tubers while the zero K_2O treatment produced 10.2 percent.

Results from some Alaskan research reported by Laughlin and Dearborn (1960) showed that **spotted leaf necrosis and tuber lesions common to potatoes grown in the Matanuska Valley were caused by a deficiency of potassium.** Soil and foliar applications of potassium both helped reduce the severity of the disorder.

AFTER-COOKING DARKENING

The influence of nutrition on after-cooking darkening of potatoes has been studied in considerable detail.

Lujan and Smith of Cornell (1964) found potash had a detrimental effect on after-cooking darkening of potatoes. They found that KCl caused more discoloration than K_2SO_4. The amount of discoloration was also directly related to increasing rates of application.

These findings conflicted with earlier English results that indicated both KCl and K_2SO_4 help prevent darkening. It was noted that the N/K ratio affects the tendency of tubers to darken.

Some years ago Schroeder and Albrecht (1942) reporting on some work done in Missouri showed that **the Ca/K ratio was important in determining the incidence of scab on potato tubers.**

TO FIGHT LATE BLIGHT

In 1956, the author became interested in the effect of fertilization on susceptibility of potatoes to late blight. Experiments were conducted in the field and the greenhouse, using Caribou loam and the Katahdin variety as host plant.

FOR THE GREENHOUSE experiment, the fertilizer treatments on an acre basis were N: 0, 120, and 240 pounds in the form of ammonium sulfate; P_2O_5: 0, 180, and 360 pounds from triple phosphate; and K_2O: 0, 180 and 360 pounds in the form of potassium chloride.

The results for the greenhouse study showed that **phosphorus and potassium were both effective in reducing the incidence of late blight.**

FIELD TRIALS were conducted on the permanent fertility plots at Aroostook Farms, Presque Isle, Maine. Nitrogen treatments on these plots ranged from 60 to 210 pounds per acre in 30-pound increments. Six phosphorus treatments ranged from 0 to 350 pounds in 70-pound increments. Potassium varied from 0 to 250 pounds in 50-pound increments.

The graph shows results of the field trials:

1. An increase in nitrogen fertilization increased the incidence of late blight.

2. Increasing amounts of phosphorous and potassium decreased the incidence of late blight.

Research results show that nutrition does affect the incidence of disease and other disorders in potatoes —and increasing amounts of potassium generally suppress the effect.

It would appear that any time potassium is in short supply, the application of additional increments of potassium increases the potato plant's ability to resist disease.

Cases that differ from this generalization usually come from areas where potassium is present in adequate supply, as a result of previous fertility management. Additional amounts of potassium upset the nutritional balance and detrimental effects might be noted.

Plant health is a matter of nutrient balance.

THE END

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200 BUSHEL CROP CONTAINS (STALK + GRAIN)

325	lbs./A.	Nitrogen
125	"	Phosphate (P_2O_5)
250	"	Potash (K_2O)
60	"	Magnesium
50	"	Calcium
35	"	Sulfur
3	"	Micronutrients

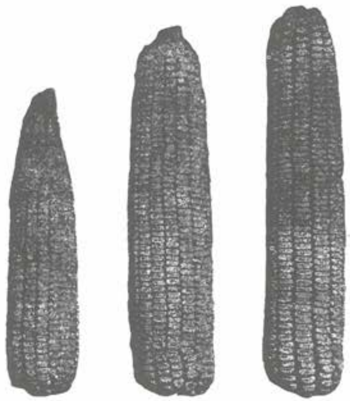
Zn + B + Mn + Cu + Mo

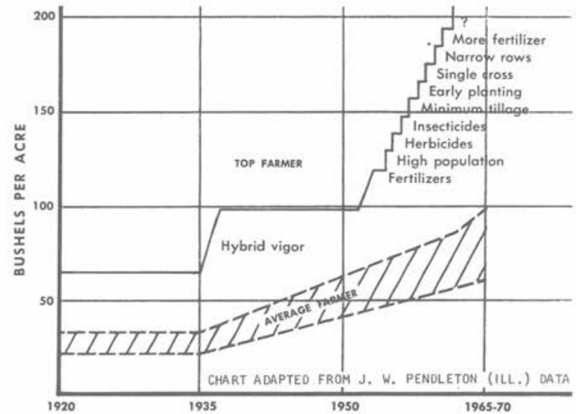
STANDS – CHECK THEM

Row Width	Length of row for 1/1000 A.
20"	26' - 1"
30"	17' - 4"
36"	14' - 6"
40"	13' - 1"

Measure or step off length of row equal to 1/1000 A.

Count number of stalks and multiply by 1000.





SIMPLE CORN ARITHMETIC

Number x Weight per Ear = Yield per Acre

Ears Harvested per Acre	Average Weight per Ear - lbs. (15.5% moisture) .5 lb. Bu.	.6 lb. Bu.	.7 lb. Bu.	.8 lb. Bu.	.9 lb. Bu.	1.0 lb. Bu.
30,000	214	257	300	343	386	429
28,000	200	240	280	320	360	400
26,000	186	223	260	297	334	371
24,000	171	206	240	274	309	343
22,000	157	189	220	252	283	314
20,000	143	171	200	228	257	286
18,000	129	154	180	206	232	257
16,000	114	137	160	180	206	229

- **PRACTICE YEAR-ROUND FERTILIZATION.** Avoid spring rush and stuck spreaders with FALL-WINTER applications. Good time to get MUCH of your phosphorous and potassium on most soils — and some of the nitrogen as advised. Lime by soil test. Check zinc and sulfur needs.
- **PLANT EARLY.** Each day's delay after May 1 can reduce your yields one to two bushels per day in the Cornbelt.
- **NARROW YOUR ROWS.** Get 5% to 10% increases with 20-30 inch rows. Convert when yields exceed 125 bushels and/or machinery needs replacing.
- **KNOW YOUR VARIETY.** Study yield trials. Different varieties respond DIFFERENTLY to heavy stands and high fertility. Try new hybrids.
- **GET THICK STANDS.** You can't get blood out of a turnip — nor extra ears from plants that aren't there! Use this corn arithmetic chart. High populations PAY!
- **TILL SOIL RIGHT.** Keep it loose. Reduce trips over the field.
- **CONTROL INSECTS.** Lick soil insects and the corn borer before they lick you.
- **PREVENT WEEDS.** Is your weed tax high? Just ONE giant foxtail per foot of row can CUT YIELDS 7 BUSHELS PER ACRE.
- **HARVEST ALL OF IT.** Earlier to insure less down corn. Recheck combine to reduce loss.

ARE THESE YOUR PROFIT-MAKERS OR PROFIT-TAKERS? REMEMBER: HIGH YIELDS NEED HIGH NUTRIENTS.
Fertilize ENOUGH and Be Open To New Ideas . . . Keep Trying!

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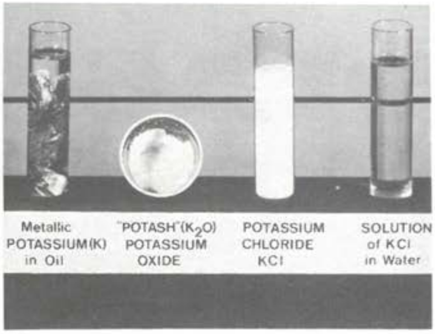

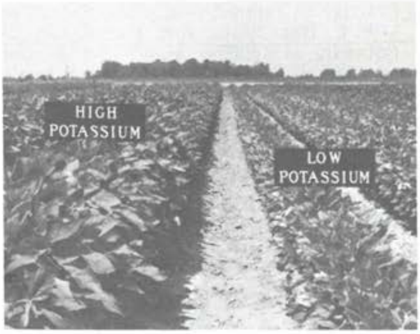

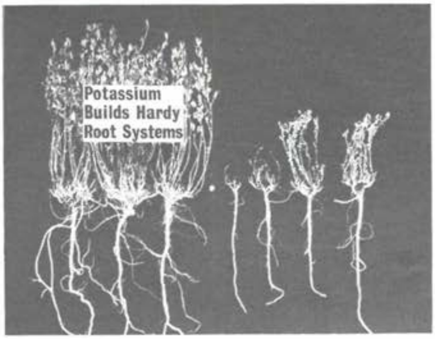

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POTASSIUM & I

MORE ON THE RELATIONSHIP FROM SELECTEI

APRICOTS

Regular annual soil topdressings of KCl at two pounds per tree improved the potassium level of the leaves and helped to control Sclerotinia fructicola.—**G. C. Wade. Australian J. Agric. Res. 7, 1956.**

BARLEY

Increases in yield and test weight and decreases in percent of thin kernels were evident from applications of both phosphorus and potassium when yellow dwarf virus disease was severe.—**T. L. Jackson, et al. Oreg. Exp. Sta. Tech. Bul. 65, 1962.**

The incidence of net-blotch of barley (Helminthosporium teres) decreased with a high dosage of K.—**S. Sing. Indian Jour. Agr. Sci. 33, 1963.**

BEETS

Clay pot tests, with freshly collected naturally infested field soils, showed that damping-off of beets, caused by Pythium ultimum, can be significantly reduced by using nitrate nitrogen and potassium fertilizers.—**J. W. Yale Jr. and E. K. Vaughn. Phytopath. 52, 1962.**

BERMUDAGRASS

Severe leaf spotting has occurred on Coastal bermudagrass on plots with a low supply of available potassium. Major disease injury was confined to the no potassium and high nitrogen plots. —**E. M. Evans, et al. Agric. Exp. Sta., Auburn Univ., Bul. 337, 1961. Also E. M. Evans, et al. Highlights of Agr. Res., Auburn Univ., 1964.**

Helminthosporium leaf spot was severe on midland bermudagrass when fertilized with nitrogen and deficient in potassium. Fertilizing with potassium increased resistance to the disease.—**C. B. Kresge. Md. Agr. Ext. Service Agronomist 1 (2), 1964.**

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Potassium chloride reduced the incidence of stalk rot and increased the percent of standing corn in the Maryland Eastern Shore region.—**Md. Agr. Exp. Sta. Ann. Rept., 72, 1960.**

Applications of potassium significantly decreased the incidence and severity of leaf blight (Helminthosporium turcicum) on corn.—**Dr. Bogyo. Potash Review, Subj. 23, 1955.**

Potassium fertilization reduced stalk rot infection (Diplodia zeae) in plots receiving 50 and 100 kg/ha of K_2O compared to plots receiving no K_2O. **Jose Guevara Calderon, Instituto Naciona de Investigaciones Agricolas.**

COTTON

Potassium helped to control cotton wilt disease —**L. E. Rast. Jour. Am. Soc. Agron. 14, 1922.**
Potassium fertilizer aided in the control of cotton "rust". Liberal and balanced fertilizer helpec control cotton wilt caused by the fungi Fusarium vasinfectum.—**D. C. Neal. Miss. Agr. Exp. Sta. Bul. 248, 1928.**

Sufficient K to control "rust" greatly reduces amount of cotton wilt.—**V. H. Young and J. O. Ware, Ark. Ext. Circ. 303, 1933.**

Potash decreased the percentage of wilted (Fusarium vasinfectum) and dead plants by 23%. —**P. A. Young, 52nd Ann. Rept. Texas Agr. Exp. Sta., 1939.**

Plots without K had definite signs of rust and were more difficult to harvest than plots with high rates of K.—**E. G. Morrison, Miss. Agr. Exp. Sta., Miss. Farm Res. 20 (8), 1957.**

A high level of nitrogen with a medium level of phosphorus and a low level of potassium was most favorable for damping-off of cotton caused by Rhizoctonia solani. A high level of potassium with low or medium nitrogen and phosphorus restricted its severity.—**J. P. Zyngas. Abs. Soils and Ferts. 26 (5), 1963.**

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Where there is adequate potassium and good management the black leaf problem on grapes can be lessened or corrected.—**W. J. Clore and C. G. Woodbridge. Pacific Northwest Fertilizer Conference Proceedings, 1964.**

POTATOES

Potatoes fertilized with K were less susceptible to blight.—**Mass. Sta. Rept., 1916.**

Plants from low K plots were more susceptible to Rhizoctonia, mosaic, and leaf roll.—**J. J. Janssen. Am. Pot. Jour., 1930.**

Increasing the potassium application to 360 pounds per acre reduced the incidence of hollow heart from 77 to 42 percent.—**A. Kallio. Am. Pot. Jour., 37, 1960.**

The blackening of potato is associated with the production of melanine through enzymatic oxidation of tyrosine. Free tyrosine is increased by nitrogen fertilization when potassium is in short

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DISEASE

REFERENCES

supply. Adequate potassium prevents the accumulation of tyrosine by nitrogen.—**W. Werner. Kartoffelbau 1, 1961. Also E. G. Mulder, Netherlands J. Agric. Sci. 4, 1956.**

Stem end rot caused by a Fusarium species was reduced on high potassium plots.—**P. J. Brewer. African Jour. of Agr. Sci. 5, 1962.**

Potassium is an important factor in preventing the development of internal black spot of potatoes.—**R. Kunkel. Wash. Agr. Exp. Sta. Cir. 451, 1965.**

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Omission of N, P, or K from the nutrient solution increased Fusarium disease severity. Addition of any of these, especially K, to the basal solution reduced disease severity.—**C. C. Chi and E. W. Hanson. Phytopath. 51, 1961.**

RICE

A fertilizer program designed to improve yields on stem-rot infested land, should include sufficient potassium to minimize the losses caused by stem rot (mainly Sclerotium oryzae).—**E. M. Cralley, Ark. Agr. Exp. Sta. Bul. 383, 1939.**

Blast caused by Piricularia oryzae increased with nitrogen fertilization. Applications of potassium increased resistance.—**R. E. T. deMello, Tropical Abstracts 16 (12), 1961.**

SUGAR CANE

P and K applications have reduced severity of brown stripe disease in sugar cane.—**J. P. Martin. Hawaiian Sugar Planters Assn. Exp. Sta. 1938.**

SWEET CORN

K deficient seedlings were severely infected with Phytomonas stewarti, whereas N and P deficient seedlings were only slightly affected.—**E. L. Spencer and G. L. McNew. Phytopath. 28, 1938.**

TIMOTHY

K reduced the severity of leaf spot (Heterosporium phlei) on timothy. At high applications of K the disease was practically eliminated.—**W. M. Laughlin. Agron. Jour. 57 (6), 1965.**

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High potash and low nitrogen increased resistance to blackfire (angular leaf spot disease).—**E. E. Clayton, Jour. Agr. Res. 55 (12), 1937.**

High potassium decreased the monosaccharide and free amino acid content and susceptibility to such diseases as Alternaria, Cercospora, and Sclerotinia.—**E. K. Klein. Bayer, landw. Jb. 33, 1956.**

Excess of N fertilization caused higher incidence of leaf spot (Alternaria longipes), while increased P and K fertilization decreased incidence.—**B. E. J. Wheeler. Kew, England. Commonw. Mycol. Inst. Misc. Pub. 15, 1958.**

Kentucky 16 tobacco showed a high incidence of wildfire caused by the bacteria Pseudomonas tabaci. Damage was much more severe at the lower rates of potassium.—**W. O. Atkinson and G. W. Stokes, Ky. Agr. Exp. Sta. 72nd Ann. Rept. 1960.**

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The weight of fruit of potassium-deficient plants is raised and the percentage of blotchy fruit reduced, either by increase of potassium supply or by increase of light.—**H. L. White, Ann. Applied Biol. 25, 1938.**

The no-K plots were the only plots with very poor yields which had a large proportion of fruit affected by vascular browning, "gray wall".—**J. L. Malcolm. Fla. Agr. Exp. Sta. Ann. Rept., 1955.**

High K significantly reduced internal browning in tobacco mosaic virus inoculated plants. High P had little effect.—**S. Rich. Phytopath. 48, 1958.**

An inverse correlation, intensified by a temperature variable, was found between potassium nutrition and blotchy ripening of tomatoes which is caused by tobacco mosaic virus. The incidence of the disease increased under low potassium nutrition.—**J. P. Jones and L. J. Alexander, Phytopath. 52, 1962.**

Inadequate K increased blotch ripening. Iron nutrition, light, and humidity were varied in the experiments but had no influence on blotchy ripening or interaction with K.—**G. H. Collin and R. A. Cline. Ontario Dept. Agr., Ann. Rept. Agr. Res. Inst. of Ont., 1965.**

The percent of fruit showing gray wall was lowest in low nitrogen-high potash plots and highest in high nitrogen-low potash treatments.—**N. C. Hayslip and J. R. Iley. Better Crops With Plant Food, 1965.**

High rates of potassium produced tomato fruit with significantly less blotchy ripening in respect to white tissue than the plots receiving no potassium.—**P. A. Minges and E. Boutonnet. Proc. XVII Inter. Hort. Congress 1, 1966.**

Sand culture experiments have demonstrated that necrotic stem lesions form on tomatoes only on potassium deficient plants supplied with ammonium nitrogen.—**A. V. Barker, D. N. Maynard, and W. H. Lachman. Proc. XVII Inter. Hort. Congress 1, 1966.**

WHEAT

K decreased susceptibility of wheat to leaf rust. —**R. D. Doak. Phytopath. 21, 1931.**
K on wheat reduced rust.—**H. de Vivie de Regie and P. Genieys. La Potasse 83, 1935.**

The most severe attacks of powdery mildew occurred when nitrogen and phosphorus were given without potassium.—**M. B. Glynne. Plant Path. 8, 1959.**

FERTILIZATION FIGHTS TURF DISORDERS

BY W. L. PRITCHETT AND G. C. HORN
FLORIDA AGRICULTURAL EXPERIMENT STATION
GAINESVILLE, FLORIDA

FEW competent turfgrass managers would depend solely on fertilizers for control of turf diseases and insects—but there is growing evidence that the fertilizer program can reduce severity of an infestation. Let's look at some turf disorders related to the fertilizer program.

FERTILIZATION AND DISEASES

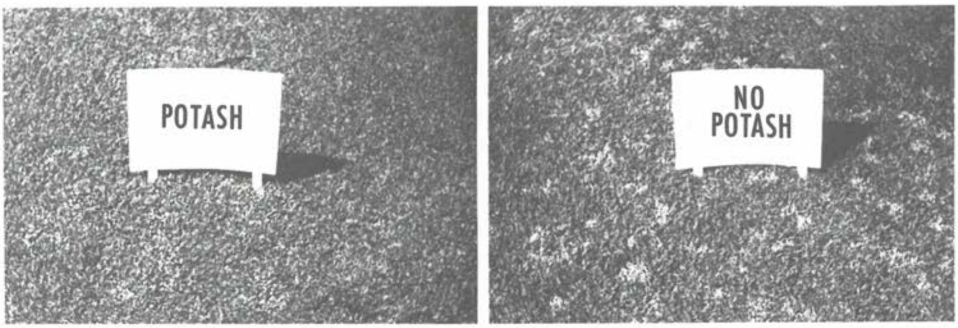
Plants deficient in a nutrient or nutrients are more susceptible to certain diseases than plants containing proper balance of plant nutrients.

James L. Holmes, midwestern agronomist, U. S. Golf Association, reported "fungi vary in their pathogenic severity according to the availability of nutrients to the grass." He found that "brown patch (*Rhizactonia solani*) and pythium blight (*Pythium aphanidermatum*) are more troublesome when nutrient levels are high. Therefore, the practice of reducing fertilizer rates during hot weather is generally and properly practiced."

Pennsylvania State University research has also shown that susceptibility of bentgrass and bluegrass to brown patch, pythium blight, and dollarspot (*Sclerotinia homoeocarpa*) can be altered by certain fertility and moisture combinations. Brown patch increased with increasing rates of N only when P and K were not concurrently increased. Dollarspot was more severe under low fertility than under high fertility programs.

Furthermore, Eliot C. Roberts at Iowa State University found that the severity of infestation of a *Helminthosporium spp.* and *Curvularia spp.* complex on bluegrass and fescue was much less in plots receiving 20 pounds of N per 1,000 square feet from urea-formaldehyde than in plots receiving 2 pounds of N from ammonium nitrate. In addition, he

13.5 Spots Per Leaf **LEAFSPOT** **147.5 Spots Per Leaf**



Good Resistance **DOLLARSPOT** **Under Attack**

found that 2 pounds of N per 1,000 square feet helped reduce rust infestation when bluegrass was watered at an optimum rate.

LEAFSPOT & K HUNGER

Auburn University researchers related the severity of leafspot fungi on bermudagrass directly to potassium deficiency. Plots with potash (NPK-Lime treatment) averaged only 13.5 spots per leaf. But plots without potash (NP-Lime treatment) averaged 147.5 spots per leaf.

Other studies have indicated that leafspot diseases (*Helminthosporium spp.*) are more prevalent when the supply of K to turfgrasses is limited. For example, the Alaska Experiment Station recently reported that leafspot (*Heterosporium phlei*) on timothy declined rapidly with adequate K.

TABLE 1—LEAFSPOT DECLINED ON TIMOTHY WITH ADEQUATE K

K lb./A	July 9 Cutting	August 14 Cutting
0	2.9	2.5
66	1.0	2.3
133	0.1	0.3
266	0.2	0.0

0=no leaf spots; 3=very many.

The effect of nutrition on disease severity may be due simply to the capacity of good vigorous turf to outgrow or resist the disease.

This is apparently true of dollarspot. In Florida, Freeman controlled

---

Dollarspot work above on Bermudagrass done at Florida University.

Leafspot work above on Coastal Bermudagrass done at Auburn University.

TABLE 2. SOURCE OF POTASH ON YIELD AND DOLLARSPOT IN BERMUDAGRASS

SOURCE OF POTASH	AVG. YIELD PER CLIPPING	DOLLARSPOT RATINGS*
	gm/1,000 sq. ft.	
KCl	1690	7.3
K_2CO_3	2350	8.5
K_2SO_4	2440	8.0
KNO_3	1650	5.8
$CaK_2P_2O_7$ (frit)	1550	6.7
FN519 (frit)	1630	7.4
Green sand	1810	4.8
Check (no K)	1680	6.8

* Rating of 1 = very heavy infestation, 9 = no dollarspot fungus.

this disease on bermudagrass by applying one pound soluable N per 1,000 square feet per month. Other nutrients were not limiting.

Though N use gives economical control of dollarspot, this practice may increase other fungus disease problems. High N rates cause tender, succulent leaves—a turf more susceptible to invading fungi. So, proper nutrient balance is basic to healthy, vigorous grass.

A TOUGHENING ROLE

Many reports mention the value of increasing potassium in grass tissue to decrease disease damage. In many instances, this disease tolerance apparently came from increased grass vigor following potash applications to K-deficient soils. Soft, easily-crushed leaves of K-deficient plants enable pathogens to enter.

But don't overlook the role of K in a plant's chemical balance. It may possibly be a mechanism for creating disease resistance. In fact, H. D. Hampton of Texas A & M University reported K-deficient plants contain high concentrations of sugars and nitrates which favor the development of organisms.

When University of Florida scientists applied 7 sources of potash at varying rates to Tifway bermuda, they found significant difference in grass yields and dollarspot disease among K sources.

Two pounds K per 1,000 square feet per year produced quality turf on a sandy soil (Arredondo loamy fine sand). Plots receiving K_2CO_3 (cotton-burr ash) and K_2SO_4 excelled plots receiving other soluble or slowly-soluble sources. See Table 2.

There were no differences in K content of the soil or in grass tissue among the sources, except grass receiving "green sand" and grass in the check plots contained less K than grass in all others. However, an analysis of the particular K_2CO_3 used in these experiments indicated it contained appreciable sulfur, hence sulfur (S) was suspected of being the nutrient reducing dollarspot invasion.

But remember: the experiment was conducted on a phosphatic sand and no sulfur-containing fertilizers were used, except treatments involving K_2SO_4 and the particular K_2CO_3 used. Later research applying S-containing fertilizers proved this element was indeed deficient in these soils, and S as well as K was partially responsible for turf resistance to dollarspot.

Don M. Huber, University of Idaho, and others, reported that the type of N taken up by the plant (although they did not work with turf) influenced its susceptibility to various soil-borne diseases. Nitrate N decreased the severity of many diseases caused by species of *Fusarium, Rhizoctonia,* and *Aphanomyces,* while ammonia N aggravated them. On the other hand, diseases caused by *Verticillium* and *Streptomyces* were decreased by the ammonia form of N, but increased by the ni-

TABLE 3. SOURCES AND RATES OF NITROGEN AND CHINCH BUG DAMAGE* TO ST. AUGUSTINE

SOURCE OF NITROGEN	N applied, lbs/1000 sq. ft/yr. 4	8	16
MINERAL	8.3	6.6	3.7
ORGANIC	8.7	8.6	7.8

* Rating scale 9.0 = no damage; 1.0 = grass dead.

trate form. They believe that the host resistance or the activity of the pathogen, or both, are changed by the form of N.

ARE INSECTS CHOOSY?

Insect damage is said to be more severe on highly fertilized turf than on moderately fertilized grass. Insects apparently prefer more succulent, vigorous grass. This is undoubtedly true for certain insects.

In south Florida, nitrogen fertilizers are withheld from lawns during midsummer to reduce army worm and sod webworm damage. On the other hand, Florida University's S. H. Kerr found that extra N and water improve appearance of mite-infested bermudagrass and help control infestation. Furthermore, fertilization may affect the plant's chemical composition enough to increase turf tolerance to some insects.

We have noted how a fertilizer program can influence the nematode infestation of grass roots. Nitrogen and potash did not affect the nematode counts on two grasses. But as phosphorus increased, the parasitic nematodes decreased—the highest count in turf receiving one pound phosphorus, the lowest in turf receiving 4 pounds P per 1,000 square feet.

Was the nematode damage reduced directly or indirectly by fertilizer? We do not know. Under some conditions, damaged roots are probably restored faster in fertilizer-fed turf than in nutrient-deficient turf, apparently reducing infestation. But this was probably not the case in this experiment, since P was not deficient in the soil and the use of the higher P rate did not stimulate top growth.

In another Florida experiment, where 3 rates each of N, P, and K in all combinations were applied to St. Augustinegrass, each plot was split for half to receive an organic source and half to receive a mineral source of nitrogen. No insecticides were used, and by August chinch bug damage was found to be closely related to the fertilizer program.

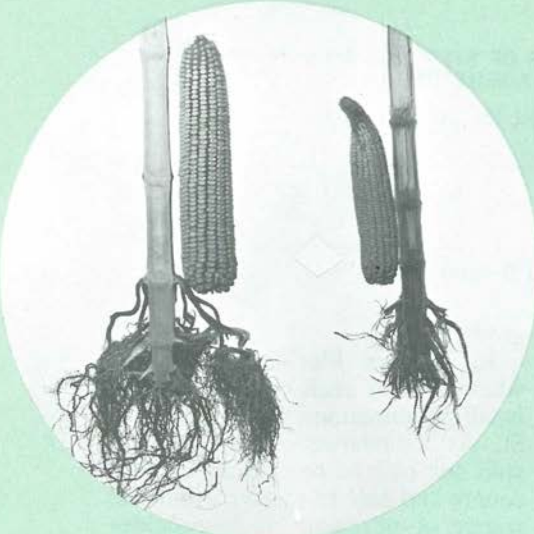
Chinch bug damage increased slightly with increased superphosphate and decreased slightly with increased KCl—but most striking relationship was with N sources and rates (Table 3).

St. Augustinegrass fertilized with 16 pounds (NH_4NO_3) of N per 1,000 sq. ft. per year was mostly killed out by the chinch bugs, while grass receiving only 4 pounds N from this source was only slightly damaged. When a process tankage was used as the N source, little damage was noted from chinch bugs—even at the highest application rate.

The damage difference between plots receiving highest and lowest rates of mineral N may have been due to succulence of different growth rate. Yet, effect of the organic source was not entirely related to growth rate, since plots receiving tankage treatment were yielding about as much clippings as plots getting NH_4NO_3 just before the chinch bug invasion.

Very few turf diseases or insects can be completely controlled by fertilizer adjustments. But, the job of control with pesticides can certainly be made much easier and less expensive by maintaining strong grass growth through a well balanced fertilizer program.

THE END



POTASSIUM HUNGER INVITES OPEN HOUSE

WHAT CAUSED THIS BREAKDOWN—from ripe ear on green stalk (left) to chaffy ear on dead stalk (right)? Potash starvation led to early stalk death, disintegrating tissues, small root system mostly rotted. Undernourished crops are ripe targets for disease: primary and secondary attackers.

WHY are potassium-starved plants more susceptible to disease than well nourished plants?

We don't know the exact reasons —just as we don't understand many of the functions of potassium in the plant.

Of course, it doesn't take a Nobel chemist to realize potassium itself does not act as a disinfectant or chemical disease preventative. Potassium-hungry plants run down early—their cells die, their tissues deteriorate, issuing open house invitation to invading organisms.

Potassium is vital to certain physiological functions of the plant—including photosynthesis, translocation of carbohydrates, and transformation into normal tissues or storage products. The normal nitrogen cycle —SALTS to AMINO ACIDS to PROTEINS—also depends on adequate potassium.

Let's look at some signs in potassium-starved plants. They may give some keys to future disease problems:

Structural Abnormalities

- Shorter plants, short internodes.
- Smaller root systems, often brown and decayed. May result in early or late root lodging of corn.
- Thin cell walls in stalks or leaves. May help explain weak stalks and more lodging of grains and corn. Thinner cell walls might make invasion easier for disease organisms.
- Marginal yellowing followed by "scorch" is a typical K-hunger symptom on many types of leaves: corn, soybeans, cotton, tobacco, potatoes, peaches, cherries, grapes, etc. But the reasons for this marginal disorder are not yet fully explained. Such abnormal leaves are poor sugar manufacturers.
- Tomatoes drop their fruits when starved for potassium. Why?

WHY?

BY HERBERT L. GARRARD
GARRARD AG PHOTOS
10 HEATHER LANE
NOBLESVILLE, INDIANA

IS THIS LEAF DISEASED?—Looks like it. But actually it is advanced stage of potash starvation in soybeans—following the early yellowing, browning, and finally shedding of leaf tissues. Undernourished crops are ripe targets for disease: primary and secondary attackers.

- Low K cucumbers have small stem ends and enlarged blossom end, just the opposite of N-starved cucumbers.

Physiological Abnormalities

- Tissue tests usually show high unassimilated nitrates and phosphates. Probably due to slow growth and functioning in the translocation and transformation of carbohydrates.
- Accumulations of certain sugars in stalks at times, apparently also due to slow utilization in growth or storage functions.
- Disruption of nitrogen cycle, with accumulations of non-protein nitrogens, abnormal amino acid proportions, as well as NO_3.
- Abnormal accumulations of iron and other metals in corn nodes which tend to stop up the "plumbing" system.
- Plants depending on storage of sugars or starch for energy for regrowth or reproduction (as alfalfa, sugar beets, potatoes, sweet potatoes) fail to fully satisfy the normal storage requirements.

Diagnostic Approach

When you find abnormal or low-yield plants in a field, use a diagnostic approach—what condition or combination of conditions caused it?

If diseased condition exists, was it caused by a primary agent or a secondary agent favored by physiological breakdown?

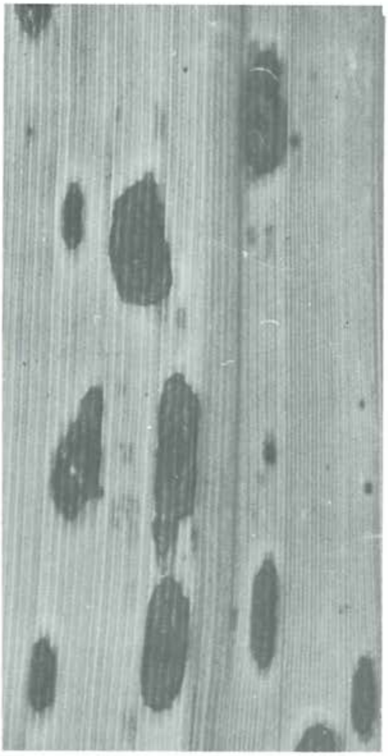
The agent causing corn lodging, for example, can do its main damage a couple of months before root or stalk breakage happens. Did the stalk die too early from K starvation? Did wet soil and root-eating insects cut nutrient intakes, reduce root anchorage, foster biological infections?

Look for ALL possible unseen causes when diagnosing problems.

THE END

RICE DISEASES and POTASSIUM DEFICIENCY

H. R. von UEXKUELL
TOKYO



BROWN SPOT ➡ **"NORMAL"**

RICE is the staple food for more than half the world's population. Rice production is the major source of income for more than 60% of the world's farm families. No wonder most countries strive to increase rice production.

Fertilizer—especially in combination with high yielding, fertilizer-responsive varieties—is a key factor in increasing rice yield. But with higher yield, losses from disease tend to increase both in absolute and in relative terms. For example . . .

1—The closer spacing of plants required for high yield create a better environment for disease infection.

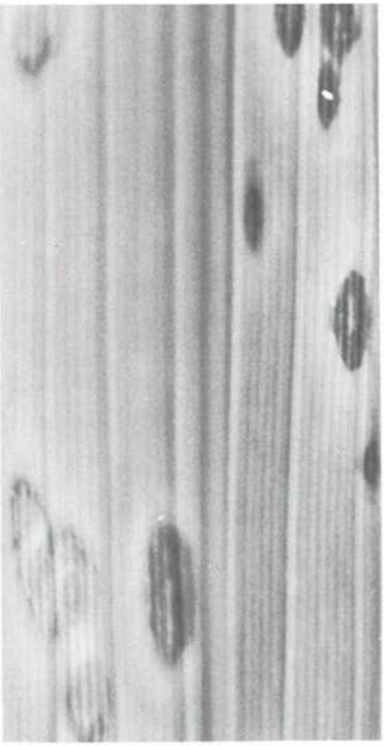
2—High yielding varieties are often less resistant to disease.

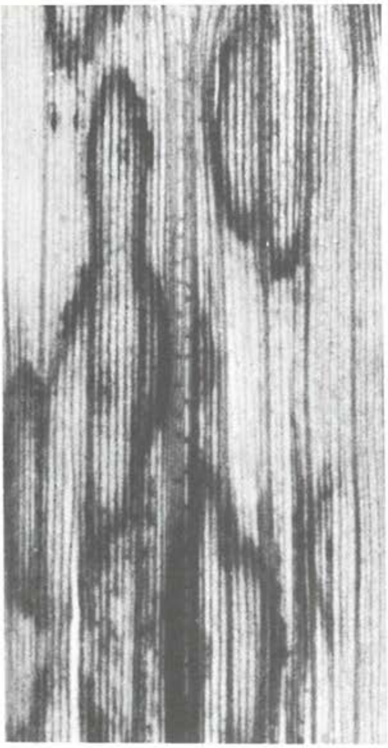
3—High nitrogen level in the plants —prerequisite for high yield— is usually related to decreased disease resistance.

4—Nutritional imbalances, resulting in weakened disease resistance, are more likely to occur under high yield levels.

In Japan, between 3-8% of the total rice crop is lost to disease. But for effective control measures, these losses would run even higher. **In other countries, where disease control is not yet as widely practiced and where fertilizer application is less balanced, such losses may be even higher.**

Among the rice diseases we have to distinguish between parasitic diseases, caused by fungi and bacteria, and physiological diseases caused by environmental factors which re-





WITH N HUNGER **WITH K HUNGER**

On "normal" plants with good potash status, spots are usually small. The disease stays close to seat of infection. But on potash deficient plants, the spots grow large, engulf more of the plant. Unlike most disease conditions, nitrogen hunger also favors this disease.

sult in nutritional disorders.

PARASITIC RICE DISEASES

The occurrence or severity of parasitic rice diseases is usually increased by excessive nitrogen and deficient potash and vice versa. But the degree to which potash effectively decreases disease damage varies greatly by the type disease. See Table I.

Potash is highly effective with Brown Spot, Stem Rot, and Bacterial Leaf Blight—and some positive effects are also reported with Sclerotial disease, Cercospora leaf spot, and Sheath Blight. With Blast, the most serious and widespread disease, reports are rather conflicting. White tip and Brown leaf blight seem to be increased by potassium.

(1) Brown spot—Ophiobolus Miyabeanus

Potash deficiency is considered a predisposing factor for this disease. During World War II, when potash was in short supply in Japan, Brown Spot Disease and Stem Rot were the most difficult ones to control. Potassium seems to affect all phases of the disease.

Spores coming from potassium deficient plants appear to be more virulent than those grown on healthy plants.—See table 2.

Lodging follows stem rot. It happens most frequently on ill-drained or degraded paddy fields, with outbreak closely related to potash deficiency.

The germination rate of conidiospores on rice plants well supplied with potassium is significantly reduced.—See table 3.

In plants with good potash status, the growth and spread of mycelia from the infection hyphae is restricted. Diseased spots on healthy plants are usually small, indicating the disease remains localized close to the place of infection. But the spots are large in potash deficient plants. Nitrogen deficiency also favors this disease, in contrast to other diseases.

(2) Stem Rot—Helminthosporium Sigmoidum and H. S. var. irregulare Cralley et Tullis

Stem rot occurs most frequently on ill-drained or degraded paddy fields, with outbreak closely related to potash deficiency. The disease becomes more severe when high levels of nitrogen are used (see Graph No. 1 and Photo No. 2). Among the two causing organisms, Helminthosporium Sigmoidum var. irregulare Cralley et Tullis (which is more frequently found on well-drained fields) seems to react less sensitively to potash. So, the effect of K on this fungus is less obvious.

(3) Bacterial leaf blight—Xanthomonas Oryzae

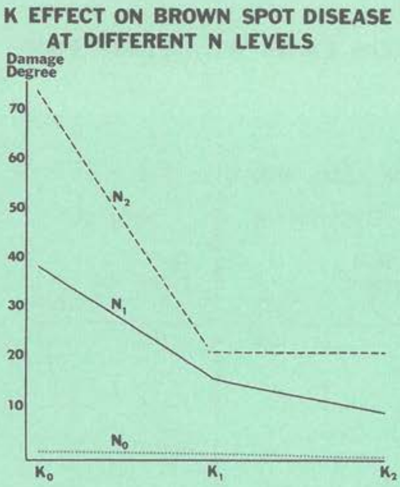
As shown in Graph No. 2 potash can be very effective in decreasing the damage caused by this disease, especially if the plants are oversupplied with nitrogen. Other factors must also be involved, because potash failed to show clear beneficial effects in some instances.

(4) Sclerotial disease (Leptosphaeria salvinii Catt or Sclerotium Oryzae sativae), **Cercospora disease** (Cercospora Oryzae) and **Sheath blight** (Cortitium Sasaki (Shirai) Matsumoto)

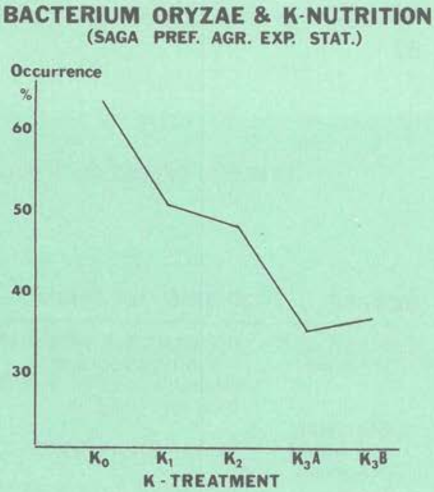
Information on the influence of nutrition on these diseases is limited. But existing data indicate these diseases appear more frequently when plants are deficient in potassium.

(5) Blast disease (Piricularia Oryzae)

Blast is the most serious and most



BROWN SPOT



LEAF BLIGHT

Potash helped decrease damage from both brown spot disease and bacterial leaf blight—especially when the plants were oversupplied with nitrogen.

universal rice disease. Reports from Italy, France, Portugal, Venezuela, Taiwan and older investigations from Japan all indicate a positive effect of potassium. But recent research in Japan has shown that under some conditions potassium significantly increased blast disease.

Excessive nitrogen is usually a strong factor in increasing the disease, and potash is needed to keep the plants in a healthy status of nutritional balance. In summarizing the role of potash on blast disease, T. Kozaka writes: **"In Japan potassium deficiency occurs particularly in fields subjected to heavy nitrogen application or in degraded paddy fields. Sufficient application of potassium, therefore, is necessary for good growth and high yield. This helps control several diseases, including rice blast."**

This is from "Control of Blast by Cultivation Practices in Japan", Symposium on The Rice Blast Disease, IRRI, p. 421-440.

(6) White tip (Aphelenchoides Oryzae Yokoo) and **Brown leaf blight** (Pathogen unknown)

Excessive potassium seems to promote these two diseases, but facts on this subject are too limited to permit clear conclusions.

NON-PARASITIC DISEASES

A number of physiological diseases are closely related to potassium. Most of them result from disturbances in the root zone caused by unfavorable environmental conditions . . .

. . . rapid decomposition of fresh

Treatment For Leaf Blight Chart Above:
N: 75 kg/ha (incl. 18.8 kg as topdressing)
P_2O_5: 75 " (Basal dressing only)
K_2O: K_0........No K
K_1........37.5 kg as basal dressg.
K_2........75 kg as basal dressg.
K_3A.......112.5 kg as basal dressg.
K_3B.......112.5 kg (incl. 37.5 kg as topdressing)

TABLE 1. EFFECT OF N AND K ON SOME RICE DISEASES

		DEFICIENT N		HIGH N	
DISEASE	CAUSING ORGANISM	Deficient K	High K	Deficient K	High K
1. Brown spot*	Ophiobolus Miyabeanus**	±	++ −	+++	−−−
2. Stem rot	Helminthosporium sigmoideum Cav. and H.S. Cav. var. irregular	−	−−	+++	−−−
3. Bacterial leaf blight	Xanthomonas Oryzae	−	−	+++	−−
4. Sclerotial disease	Sclerotium Oryzae-sativae	°	−	++	−
5. Cercospora leaf spot	Cercospora Oryzae	°	−	°	−
6. Sheath blight	Corticium Sasaki Matsumoto	°	−	+++	−
7. Rice blast	Piricularia Oryzae	−	±	+++	++
8. White tip	Aphelenchoides Oryzae Yokoo	−	+	+	− ++
9. Brown leaf blight	Unknown	°	+	?	++?

\+ disease slightly increased
− disease slightly decreased
± sometimes increased, sometimes decreased
° unknown
++ considerably increased
−− considerably decreased
+++ highly increased
−−− highly decreased

organic matter in the flooded soil under high temperatures which exhausts the oxygen in the soil and lower the redox potential (Eh).

. . . the presence of organic and inorganic reduction products such as butyric acid, acetic acid, and hydrogen sulphide are toxic to the plant and inhibit the aerobic respiration of the roots. This especially affects the absorption of potassium. **Potassium deficiency, in turn, lowers the oxydizing activity of the roots, thus aggravating the damage.**

. . . vigorous development of new roots (after transplanting or after the older roots have died) increases nitrogen absorption—but lack of oxygen and accumulation of harmful substances slow down potassium absorption. When potassium uptake cannot keep pace with nitrogen absorption, the ratio of K/N declines. Diseased plants have a K/N ratio of 0.4-0.8 against a normal ratio of 1.1-1.3. This disturbs protein and carbohydrate metabolism—increasing respiration and non-protein nitrogen fractions in the plant, weakening the healthy development of the roots, and preventing a selective, balanced uptake of nutrients.

Plants under such conditions are usually also very susceptible to stem rot (Helminthosporium) and brown spot (Ophiobolus Miyabeanus)

TABLE 2. VIRULENCE OF OPHIOBOLUS MIYABEANUS SPORES COMING FROM RICE LEAVES WITH DIFFERENT POTASH NUTRITION (AFTER MATSUO[1])

ORIGIN OF SPORE SPECIMEN	VIRULENCE OF THE SPORES No. of disease spots per 100cm leaf length	Ratio
1. Spores from the control plot (Potassium supplied throughout the growing season)	23.5	100
2. Spores from plots with a short period of K deficiency (K-deficiency after Aug. 8)	31.5	135
3. Spores from plots with a prolonged period of K-deficiency (K-deficiency after July 14)	36.6	156

TABLE 3. GERMINATION* OF CONIDIA OF OPHIOBOLUS MIYABEANUS ON RICE LEAVES FROM PLANTS GROWN WITH VARIED POTASSIUM AND NITROGEN (AKAI[2])

	Control	Excessive K	Deficient K	Excessive N	Deficient N
No. of spores per leaf	1041	980	1015	912	1002
No. of germinating spores	390	248	518	678	906
Germination rate (%)	37.7	25.3	51.0	74.3	90.4
Ratio	100	67	137	199	242

* Spores were fixed with formalin 12 hrs. after germination.

Depending on main causing factors, time of occurrence, and symptoms developed, the diseases shown in Table 4 can be distinguished in Japan.

In Summary . . .

A great many diseases, parasitic as well as physiological, are aggravated by an imbalance between nitrogen and potassium.

A good balanced supply of potassium will not only increase the yield but also help fight diseases. This side-effect of potassium will grow more important with larger nitrogen applications to meet the need for higher crop yields.

[1] Matsuo, T. 1948, on the influence of potash deficiency in soils upon the outbreak of the sesame leaf spot disease of the rice plant. Ann. Phytopath. Soc. Japan 13:10-13.

[2] Akai, S. 1962, application of potash and occurrence of Helminthosporium leaf spot on rice. Potash Review, Subject 23, 27th Suite 1-2.

[3] Prepared from figures given by K. Ono, 1952, the relation between rice diseases and potassium. 1st Japanese Potassium Congress, Tokyo, pp. 21-87.

TURN TO TABLE 4 NEXT PAGE

TABLE 4. PHYSIOLOGICAL RICE DISEASE ASSOCIATED WITH POTASSIUM

NAME OF DISEASE	COUNTRY	SYMPTOMS	TYPE OF SOIL WHERE THE DISEASES OCCUR	PRIMARY CAUSING FACTORS	PREVENTIVE MEASURES
Akagare Type I (Red withering or stiffle disease)	Japan	Leaves first turn dark green, later small, elongated reddish brown spots appear near the tips of older leaves, which in severe cases die, starting from the tips. The roots turn light brown or reddish brown. In many cases blackened or rotten roots occur. Heavy occurrence of Helminthosporium disease.	Ill-drained sandy fields. Ill-drained fields with excessive organic matter.	a) Poor natural supply of potassium in the soil. b) High Eh, low oxygen and harmful organic substances in the soil. c) Too low or too high soil temperature.	a) Liberal application of potassic fertilizers. b) Drainage of the field. (Potash is highly effective.)
Akagare Type II	Japan	First the midribs turn yellow, then reddish spots appear, first around the midrib, spreading later over the whole leaf. Root symptoms are similar as with Akagare Type I. Heavy occurrence of Helminthosporium disease.	Ill-drained fields with excessive organic matter.	a) A high contact of fresh organic matter in the soil. b) Hydrogen sulphide and organic acids in the soil. c) A low content of ferric iron in the surface soil. d) Excessive ferrous iron. e) An abnormally low Eh. f) A low potash content of the soil.	a) Liberal application potassic fertilizers. b) Use of non-sulphatic fertilizer. c) Application of red upland soil (ferric iron). d) Avoiding the use of green manure. e) Off-season drainage and/or ridging of the soil. f) Surface drainage at the ineffective tillering stage. g) Keep soil temperature low by running water irrigation. h) Use of resistant varieties. (Potash is effective, but not as effective as with Akagare Type I.)
Some types of: "Suffocating disease," "Bronzing disease," "Mentek disease"	Taiwan Ceylon Indonesia	Similar to Akagare Type I or II or "Akiochi"	Ill-drained fields with excessive organic matter. Fields low in natural K-supply.	Similar to Akagare Type II.	Similar to Akagare Type II and "Akiochi."

"Akiochi" (Autumn decline)	Japan	Vigorous or normal early growth, later decline in growth, root injury, dying of older leaves and roots. Heavy occurrence of Helminthosporium disease.	a) Degraded paddy soil. b) Ill-drained paddy soil.	a) Root injury from hydrogen sulphide. b) Root injury from hydrogen sulphide, excessive ferrous iron and organic acids.	a) Application of basic slag containing Si, Ca, Mg and Mn. b) Higher level of K and split application of K and N-fertilizers. c) Use of non-sulphatic fertilizer. d) Application of upland soil, rich in iron. e) Draining the field at 25-35 days before heading. f) Running water irrigation. g) Use of resistant varieties and early season cultivation.
"Aogare" (blue withering)	Japan	Plants show dark blue-green colour. About 20 days after heading, a sudden withering of the upper leaves takes place, which rapidly affects the whole plant.	Soils low in potassium.	a) Unbalanced application of N and K fertilizers. b) Drainage after heading, dry wind and cool air.	a) Liberal application of K-fertilizers. b) Application of compost.
Straighthead	USA Japan	Leaves and stems are dark green and stiff. Sometimes the whole plant is dwarfed with abnormally numerous leaves; weak development of rachis' branches and flowers and flower sterility.	Sandy loams, loams and clays, recently converted into paddies from uplan fields.	Unknown	a) Draining the field about 35 days before heading. b) Use of early maturing varieties. c) Use of non-sulphate fertilizer. d) Application of increased amounts of potash fertilizer.

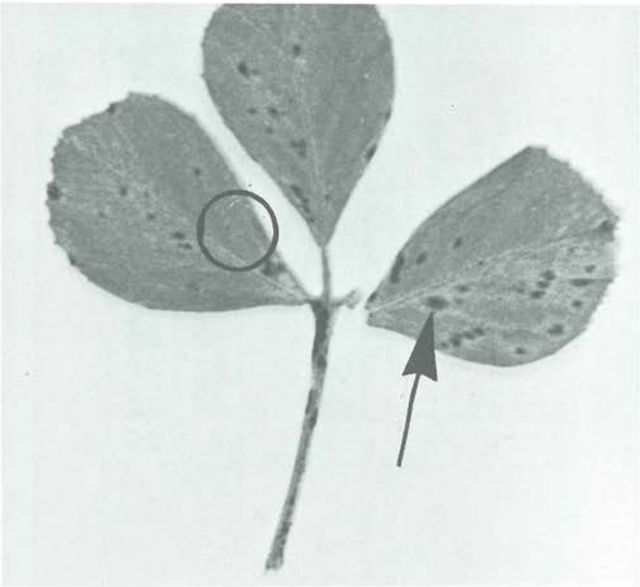
THE END

LEAF PHOTO

Actual leaf shows leafspot disease.

Arrow points to clear leafspot infection.

Circled area shows no symptoms, looks good to the naked eye.



RADIOISOTOPE UNCOVERS

BY D. D. WOLF

DISEASE saps health and productivity from a plant just as it does from an animal. But the plant cannot "talk back" or complain.

Sick plants must grin and bear it —and hope the alert grower will come to their aid.

Disease symptoms are often hidden. Damages to growth are sometimes subtle and usually tolerated since damage does not completely destroy the host plant.

This article will look at one result of a disease infection in a plant— **increase in respiration rate.**

HOW BREATHING RATE RISES

Relatively rapid respiration rates in diseased tissue have been shown, through elaborate measures of oxygen used and carbon dioxide evolved.

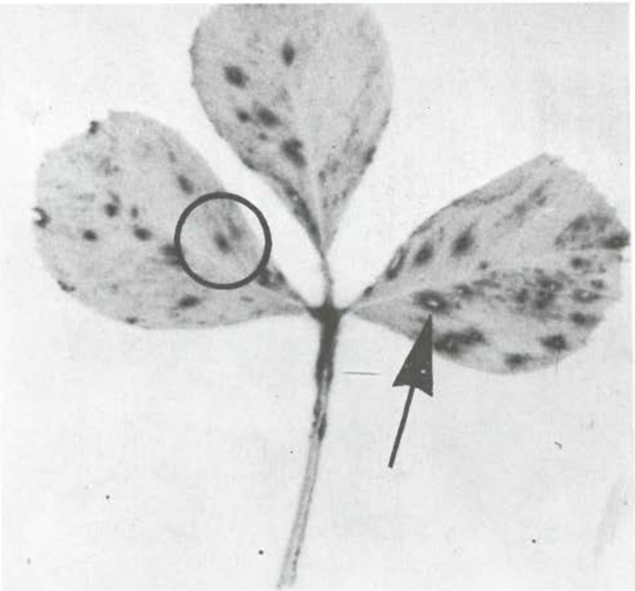
The respiration process occurs in all normal living plant cells, using up manufactured food (sugars and other carbohydrates) to get energy for growth. When disease strikes, respiration of the infected cell increases rapidly, "burning up" or wasting energy at the expense of plant growth. The condition can be thought of as a "fever." In fact, such tests have actually shown increased temperature to indicate infestation.

EXPOSED RADIOACTIVITY

Some alfalfa plants at the University of Connecticut Agronomy research farm showed various stages of infestation of a leafspot disease (caused by *Pseudoperzia medicaginis*).

A small clear-plastic box was placed over the plants to form a closed air system. Some radioactive carbon dioxide was released into the air conditioned box. The plants took up this radioactive carbon by photosynthesis for 15 minutes, manufacturing it into usable plant food.

Immediately after the box was taken away from the plants, leaves were removed and placed in contact



X-RAY FILM

Radioactivity accumulates in leaf-spot areas of same leaf.

Arrow shows age of leafspot, with tissue at center of infected site already dead.

Circled area appears as early infection on x-ray.

PLANT DISEASE

UNIVERSITY OF CONNECTICUT

with an x-ray film. A similar sample was taken one day later.

Any place in the leaf that had accumulated radioactive carbon by photosynthesis or translocation of manufactured food would show up as a dark image on the developed film. When there was a high respiration increase in any cell, the manufactured food moved to that area and formed a dark spot on the film.

VISUAL MEASUREMENT

The entire leaf showed an overall greyish image from increased activity. Two things were apparent from leaves sampled immediately:

(1) Some dark areas occurred where no visible leafspot disease could be seen—probably indicating early infection and high respiration of these cells that will develop visible signs later.

(2) Some very light areas occurred at the center of visible leafspots—probably indicating the plant cells had been killed by the disease and could not manufacture food as normal areas did.

Another interesting event was seen when the leaves were sampled after one day:

Some very dark rings with light centers occurred where there were visible leafspots (see photo).

Through a microscope, we could see the disease was advanced enough to be forming reproduction bodies called conidia **at the expense of food manufactured by the plant.**

So we can assume respiration rate increased in the area of the spot and the organism causing the disease drew on the vitality of the plant.

Balanced nutrition is known to aid normal metabolic activity and growth —and to help plants resist disease. If these plants received adequate nutrition, the abnormal sites of respiration caused by disease might be reduced.

WHAT CAN WE DO TO HELP?

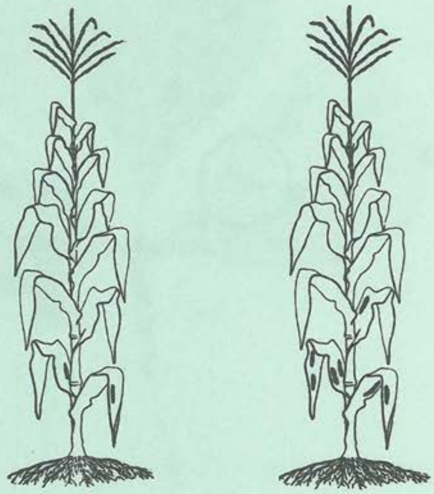
Select resistant varieties, practice good management, insure adequate fertility—and be always aware of what disease does.

THE END

POTASSIUM and Corn Leaf BLIGHT

W. I. THOMAS
D. E. BAKER
W. F. CRAIG

PENNSYLVANIA
STATE
UNIVERSITY



0.5 — Very slight infection—one or two restricted lesions on lower leaves.

1 — Slight infection—a few scattered lesions on lower leaves.

THE RELATIONSHIP of soil fertility to corn diseases has been suggested by numerous research workers, but research investigations in this area have been limited.

Reports from Iowa, New York, Ohio, and Pennsylvania indicate that **in certain soils, potassium plays an important role in reducing stalk rot.** Under other conditions the effects of potassium have not been as pronounced.

Information from Illinois and Pennsylvania also **shows more leaf blight developing on plots without potassium in the fertility treatment than on plots with it.**

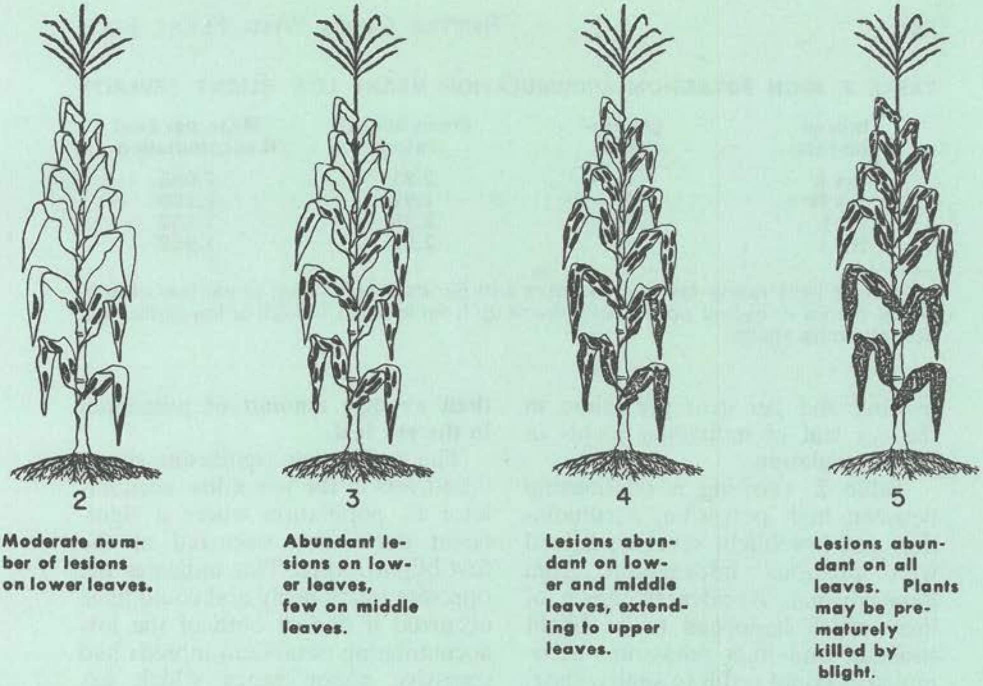
Pennsylvania research has shown the genotype of the hybrid definitely affects the accumulation of certain chemicals in the leaf tissue. But under certain environmental conditions this genetic difference is not expressed.

A high and a low potassium-accumulating single-cross corn hybrid were grown in several states. The hybrids were originally classified in 1961 at Landisville, Pennsylvania. Table 1 shows the percent potassium accumulated in the leaf of the ear node when these hybrids were grown in six states in 1964 and 1965.

The chemical analyses of the different soils have not yet been completed. But different environmental conditions apparently changed the potassium accumulating ability of these hybrids at some locations.

In 1961, Pennsylvania experiments showed that corn hybrids taking up higher amounts of potassium in the leaf tissue developed less severe leaf blight symptoms than hybrids taking up lower amounts of potassium. Hybrids taking up lower amounts of calcium and zinc in the

This research was supported in part by the U. S. Atomic Energy Commission. No. NYO-2744-31.



leaf also showed less severe leaf blight symptoms.

Individual plants of F_2 populations of three single-cross hybrids and one F_1 single-cross hybrid were classified according to the scale in Figure 1 for blight resistance on July 28, August 6, August 19 and September 10.

The leaf from the ear node of each plant was collected approximately 30 days after the silks had emerged and before blight lesions were abundant and were analyzed for potassium content. The single cross hybrids were crosses between inbreds which had previously been found to be high (H) or low (L) accumulators of potassium.

Table 2 shows the mean blight

TABLE 1. POTASSIUM IN THE EAR LEAF OF TWO SINGLE CROSS HYBRIDS

(Originally classified as high and low accumulators when grown under widely different areas, in 1964 and 1965.)

Location	Per cent potassium 1964 high	1964 low	1965 high	1965 low
Pennsylvania	1.63	1.46 **	1.93	1.49 **
Indiana	2.11	1.77 **	1.65	1.07 ns
Illinois	1.83	1.38 ns	1.62	1.14 *
Iowa	1.13	1.01 ns	.88	.91 ns
Kentucky	2.76	2.38 **	1.80	1.44 **
Missouri	1.86	1.44 **	1.99	1.40 **

** Difference between high and low was statistically significant at the 1% level.
* Difference between high and low was statistically significant at the 5% level.
ns Difference was not statistically significant.

TABLE 2. HIGH POTASSIUM ACCUMULATION MEANT LOW BLIGHT SEVERITY

Inbred parents	generation	mean blight* rating	Mean per cent K accumulation
H x L	F_2	2.81	2.086
H x H	F_2	1.97	2.340
L x L	F_2	3.58	1.852
H x L	F_1	2.56	1.962

* Mean of light rating taken on 4 dates and per cent potassium of ear leaf of individual plants in hybrid populations made up from inbreds of high or low potassium accumulating ability.

reading and per cent potassium in the ear leaf of individual plants in each population.

Table 2, showing a relationship between high potassium accumulation and low blight severity, agreed with previous information from Pennsylvania. Accidental choice of lines which happened to be blight resistant and high potassium accumulators could result in similar data.

But if inheritance conditioning blight resistance was related to potassium accumulation, a much stronger relationship would be expected between individual plant ratings of the F_2 population of the high x low lovel potassium accumulation than the others.

Table 3 shows potassium level was negatively correlated with blight rating for the F_2 of the high x low level of potassium accumulation on all four dates when blight readings were taken. **In other words, a plant with a low score, indicating resistance, was likely to have a higher than average amount of potassium in the ear leaf.**

The only other significant correlation was in the low x low accumulator F_2 population where a significant correlation occurred at the first blight rating. This indicates the opposite relationship and could have occurred if one or both of the low accumulating potassium inbreds had recessive minor genes which expressed themselves sufficiently to be classified before blight reached a severe stage.

SUMMARY

No practical recommendations or results are immediately available for using information on hereditary differences in potassium accumulation. But partial control of disease problems by increased potassium uptake from added fertilizer is paralleled by the genetic control of potassium uptake.

From a practical viewpoint, in Pennsylvania, it is easier and more

(Continued on page 13)

TABLE 3. CORRELATION COEFFICIENTS OF EAR LEAF POTASSIUM ACCUMULATION AND BLIGHT RATINGS OF INDIVIDUAL PLANTS OF 4 HYBRID POPULATIONS.

(Blight ratings were made on 4 dates.)

		Date of Blight Readings			
Inbred parents	Generation	7/28	8/6	8/19	9/10
H x L	F_2	−.228*	−.328*	−.283*	−.305*
H x H	F_2	.086	−.262	.132	−.146
L x L	F_2	.301*	.254	.125	.115
H x L	F_1	.043	.163	−.234	−.150

* Statistically significant at the 5% level.

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