



BETTER CROPS

WITH PLANT FOOD

Winter 1992-93

Featured in this issue:
Potassium...for Profitable Crop Production

BETTER CROPS With Plant Food

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Contents

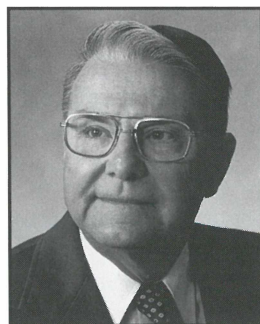
The Man from Manlius— W.L. Nelson: 1914-1992	3
Potassium Is Important for Fresh Market Quality A.E. Ludwick	4
Potassium's Protective Mechanisms for People David B. Young and Richard D. McCabe	6
Potassium Dynamics in Grass Seed Production (Oregon) J.M. Hart, D.A. Horneck, W.C. Young and T. Silberstein	8
Cotton Yield Enhancement Using Foliar- Applied Potassium Nitrate and PGR-IV (Arkansas) Derrick M. Oosterhuis	10
Research Notes: Eliminating Off-Farm Nitrogen: A Case Study (Minnesota)	11
Suppression of Anthracnose on Soybeans with Potassium Fertilizer and Benomyl (Texas) J.W. Sij, F.T. Turner and N.G. Whitney	12
Fertilization Effects on Soybean Sudden Death Syndrome (Tennessee) D.D. Howard, A.Y. Chambers, P.W. Brawley and T.D. Bush	14
Survey of Cotton Soils Shows Several Factors Related to Potassium (Alabama) C.C. Mitchell	16
Potassium-Water Relationships in Winegrape Production (California) Mark A. Matthews and Mike M. Anderson	19
Potassium Fertilization Influences Cotton Dry Matter and Yield (Mississippi) W.T. Pettigrew and W.R. Meredith, Jr.	22
Environotes from TVA John E. Culp	23
Society Doesn't Appreciate Agriculture J. Fielding Reed	24

Our Cover: Corn plants which received potassium fertilization show growth response (at left) in this Minnesota ridge-till field. The benefits of potassium for crops as well as for people are featured in this issue. Photo by Dr. Larry Murphy.

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The Man from Manlius— Werner L. Nelson: 1914-1992

Dr. Werner L. Nelson, retired Senior Vice President of The Potash & Phosphate Institute, died November 27, 1992, in West Lafayette, Indiana. He was born October 17, 1914, near Manlius, Illinois. Survivors include his wife Jeanette, son John, daughter Jean, and three grandchildren.



Dr. W.L. Nelson

WHEN Werner Lind Nelson departed for heaven the day after Thanksgiving last year, America lost a special breed of scientist—an agronomist who never allowed his higher learning to cripple his capacity to communicate like the farm boy he was.

Every Nelson word I ever read or heard moved simply and directly. Crystal clear. And not only clear, but interesting and always as accurate as the human mind could make it.

In the late 1960s, the American Society of Agronomy (ASA) elected Werner Nelson president, the first scientist from industry ever elected to that post. It brought much honor to the entire plant food industry.

At the time, those of us who had worked several years with him in the Institute knew not only what kind of scientist the ASA had elected but, more importantly, what kind of man! Personally, I found him to be quiet and unpretentious, but firm of word and action. Very firm.

Dr. Nelson was no wimp. He was no pouter. If he lost a debate, he would always work full steam ahead for the plan he didn't favor initially. He was the quintessential team man whose example rubbed off on younger scientists.

Intensely scientific, probing, wondering, he punctured complacency with a capacity for work that was staggering.

Colleagues noticed how he seemed happiest in the field, drifting from the crowd, inspecting some dead tissue in the root crown of corn plants, and returning to ask the grower what hybrid he used, what fertilizer and planting rates. In my opinion, this insatiable curiosity and the insights it

generated influenced everything Dr. Nelson ever did in his professional life:

- Serving as Senior Vice President of the Institute for over two decades.
- Receiving the coveted Bronze Tablet for leading the scholarship ranks of the huge University of Illinois in his student days of the 1930s.
- Rising to Professor in charge of North Carolina's soil fertility research and Director of the state's Soil Testing Division in the 1940s and early 1950s.
- Co-authoring the noted textbook, *Soil Fertility and Fertilizers*, now in its fifth edition.
- Leading a five-member study team of the United Nations' FAO, to look at the role of fertilizer in meeting the food needs of developing countries.
- Becoming a Fellow of the American Society of Agronomy, American Association for Advancement of Science, Crop Science Society of America and Soil Science Society of America.
- Receiving Ohio State University's Centennial Award for building bridges of cooperation among universities, growers and industry.
- Serving as adjunct professor at Purdue University and guest professor or lecturer at nine other universities.
- And, most important of all, initiating countless grower and dealer meetings designed to bring the latest helpful research findings to the field.

The list could go on and on . . .

Werner Nelson was basically, and above all, a humble man. What a powerful credential to take to heaven. ■

These comments were prepared by Sanford Wingate Martin, retired Editor of the Potash & Phosphate Institute, who worked with Dr. Nelson for many years.

Potassium Is Important for Fresh Market Quality

By A. E. Ludwick

Potassium (K) is often described as the "quality element". A shortage of K adversely affects photosynthesis, respiration, translocation, and a number of enzyme systems. This frequently results in small or misshapen produce, more disease and insect damage, and shorter shelf life.

PROFIT in vegetable and fruit production can originate from: 1) more total yield; 2) greater percentage of total yield that is marketable; better quality; and/or better efficiency (lower unit costs of production). All are important and all are directly affected by fertilizer selection and management.

Fresh Market—A Special Case

The goal in any nutrient management program should be to provide balanced nutrition throughout the growing season, avoiding deficiencies of any nutrient on the one hand and excess applications on the other.

Potassium can be a special concern in production of crops for the fresh market. It is required in large amounts, similar to and frequently greater than that of nitrogen (N). It moves to plant roots primarily by diffusion, not by mass flow as with N, so it is more subject to "environmentally induced" deficiencies such as cool soil temperature, unfavorable moisture conditions, and soil compaction. Potential deficiencies are accentuated for many vegetables because they grow rapidly and have limited rooting systems. Even under excellent management there may be short periods of reduced K uptake immediately following irrigation because of oxygen depletion affecting root respiration. Such temporary shortages can reduce yield and quality.

Potassium—Essential in Many Ways

Potassium is involved in numerous metabolic pathways within the plant. Over 60

enzyme systems are activated by K. It is difficult to imagine a growth or reproduction process in plants that is not directly or indirectly impacted in a very significant way by K. Potassium plays the following roles:

Photosynthesis

- Coloration of leafy vegetables (healthy green color)
- Uniformity of ripening
- Growth rate

Synthesis of amino acids and protein

- Food quality

Carbohydrate synthesis and translocation

- Bud development
- Sugar content
- Enhanced flavor

Lignin and cellulose development

- Firm stems and stalks
- Resistance to bruising and physical breakdown
- Longer shelf life

Disease and insect resistance

- Thicker epidermal layer
- Fewer blemishes
- Higher market grade
- Less culls and waste

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Root growth

- More effective utilization of soil moisture
- Improved nutrient uptake
- Greater root vigor

Quality—Consumers' Demand

High produce quality is essential for profitable production. Quality can be measured in many ways. High on the list for consumer acceptance is produce of uniform size, color, and maturity, with enhanced flavor, free of blemishes or unusual markings, and free of any sign of disease. Potassium plays a significant role in all of these considerations.

An example of the benefit of K on crop quality is presented in **Table 1**. The importance of balanced nutrition is also demonstrated. In this case, fertilizing tomatoes with a combination of N and K produced substantially more total yield and a dramatically greater yield of marketable fruit.

There was only a modest yield increase to applied N when K was not applied. Only

about half of the fruit was marketable. Applying K along with N more than doubled and nearly tripled yields in several cases. These higher total yields were accompanied by percent marketable yields ranging from 71 to 85.

Such examples emphasize the importance of a carefully planned nutrition program. Not only were yield and quality dramatically increased, but fertilizer use efficiency was also greatly increased. In the case of N, the greater yield would take up substantially more N, leaving less nitrate in the soil profile following harvest.

It has been recognized for decades that K will enhance plants' ability to resist disease. This is not isolated to a few crop species, but covers a wide spectrum of both plants and pathogens. Although there are many interacting factors that determine host susceptibility, K is one important management tool that is often effective in reducing the severity of attack. Frequently produce quality is directly related to the presence or absence of disease problems.

Table 1. Total and marketable yield of tomatoes are benefited by N and K nutrition.

K ₂ O, lb/A	N, lb/A		
	120	180	240
	Yield, tons/A and % marketable ()		
0	7.1(41)	7.5(56)	9.3(55)
300 (preplant)	15.1(71)	15.5(76)	16.2(77)
150 preplant+	17.6(80)	20.8(85)	26.7(85)
150 sidedress			

() = Amount (%) of total yield that is marketable.
University of Illinois

Summary

In the final analysis, K does not work alone. Rather, it functions with other essential nutrients and crop management inputs to produce the final product. The importance of balanced nutrition and efficient use of all plant nutrients is recognized. The special role of K in crop quality is of particular importance for overall production profitability. ■



ONION harvest in the Imperial Valley of California.



LETTUCE production in the Salinas Valley.

Potassium's Protective Mechanisms for People

By David B. Young and Richard D. McCabe

University of Mississippi researchers have found that consuming foods rich in potassium (K) helps keep blood vessels healthy and lowers risk of heart attack and stroke. Specifically, K helps protect blood vessel cells from atherosclerotic lesions.

THE PROTECTIVE effects of K in human and animal physiology have been demonstrated repeatedly over the past 40 years. Studies of hypertensive rats have indicated that high-K diets prevented or reduced the incidence of vascular lesions and cerebral vascular disease and had a prominent effect on animals' longevity. High levels of K in rats' diets reduced the mortality rate due to stroke by 98 percent in one study and 91 percent in a companion experiment in which blood pressures of the control and high K groups were closely matched.

The importance of the protective effects of K against stroke in humans was verified in studies of 1,000 individuals in California. A strong inverse relationship was found among the rate of K intake, the incidence of stroke over the 12-year study period and the mortality rate resulting from stroke.

Although strong evidence of a protective mechanism from K in the cardiovascular system was known, the specific nature of the effect had not been determined until recent studies at the University of Mississippi Medical Center.

Mississippi Studies

The objective of our studies was to systematically analyze the mechanisms responsible for the protective effects of K by focusing on the formation of atherosclerotic lesions in blood vessels. Atherosclerosis occurs when fat deposits build up in blood vessels, attract white blood

cells and form plaque which thickens artery walls, reduces pliability of the vessel, restricts blood flow and enhances the possibility of stroke or heart attack.

The effects of K concentrations in blood serum outside of cells were examined by in vitro studies of three types of cells that are major factors in atherosclerotic processes. First, the effects of K on blood platelet aggregation response to thrombin (clotting tendency) declined as K concentrations increased to a mid-range level (**Figure 1**). This implies a reduced

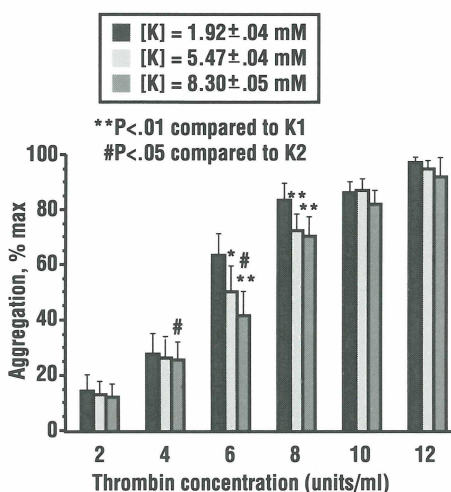


Figure 1. Effects of K on platelet response to thrombin. Higher K concentrations to mid-range were related to lessened tendency for clot formation at the surface of advanced atherosclerotic lesions.

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risk to clot formation at the surface of advanced atherosclerotic lesions.

Secondly, the effects of K on formation of reactive oxygen species or oxygen-free radicals released by white blood cells indicated that higher K concentrations inhibited this process (**Figure 2**). Reactive oxygen species (ions) react with (oxidize) cholesterol . . . low density lipoproteins (LDLs) . . . increasing the attraction of cholesterol to blood vessel walls and enhancing the tendency of plaque formation which inhibits blood flow. Higher K concentrations then suggest a lowered incidence of plaque formation.

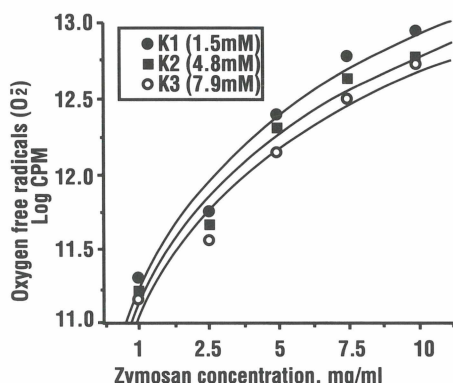


Figure 2. Higher K concentrations inhibit the formation of reactive oxygen species (oxygen free radicals, O_2^-) by white blood cells, lowering the tendency for cholesterol to form plaque on blood vessel walls.

A third area studied was the effects of K concentrations on vascular smooth muscle proliferation. Smooth muscle cells make up the underlayer of blood vessels and are stimulated into abnormal growth during the early stages of atherosclerosis when lesions are forming. Lower than normal K concentrations stimulated growth of these cells . . . higher K concentrations induced the lowest rate of growth (**Figure 3**).

Summary

Changes in K concentrations may affect the functions of these cells by several

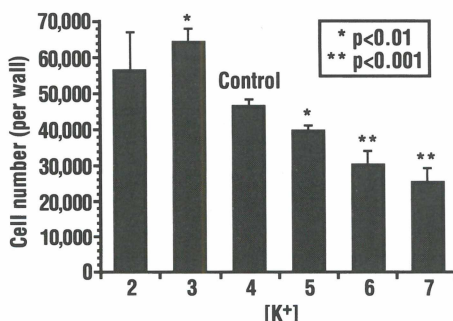


Figure 3. Higher K concentrations tend to depress the growth of vascular smooth muscle cells which are related to the development of atherosclerotic lesions in blood vessels.

mechanisms. Potassium has primary effects on two active transport systems (enzymes) in cell membranes. Increased activity of these enzyme systems brought on by higher K concentrations may affect intracellular activities of hydrogen (H^+), sodium (Na^+) and calcium (Ca^{++}) ions and a variety of cellular functions affected by these ions.

The results of these studies add to the understanding of the potential role of K intake in reducing the incidence of stroke and other forms of vascular disease. These results support the efficacy of increasing K intake as a measure of prevention or treatment of cardiovascular health at very low cost and with minimal risk. Foods containing high amounts of K, such as bananas, whole potatoes, orange juice and leafy green vegetables, are excellent sources of K. ■



FOODS such as bananas, whole potatoes, orange juice and leafy green vegetables are excellent sources of potassium.

Potassium Dynamics in Grass Seed Production

By J.M. Hart, D.A. Horneck, W.C. Young and T. Silberstein

Potassium (K) management for grass seed production differs greatly based on whether the straw is burned in place or baled and hauled away. Research is showing how best to manage the latter, a more environmentally desirable choice which removes substantially greater amounts of K from the fields.

GRASS SEED producers in Western Oregon traditionally employed open-field burning for straw disposal and field sanitation. Political pressure and increased regulation decreased the number of burn days, causing grass seed growers to modify their practices. Straw removal by baling is now the common alternative disposal method. Displacement of annual open field burning by physical straw removal interrupts nutrient cycling, especially K. When straw is burned, 6 to 7 lb/A K_2O is removed in seed. In contrast, K removed with tall fescue straw can be 35 to 360 lb/A K_2O .

Answering Questions

Growers and fertilizer dealers questioned the impact of straw removal on seed yield, the significance of rapidly declining K soil test values in fields where straw has been removed and fertilization changes necessary to maintain seed yields without field burning. To answer these questions, a 3-year field experiment was initiated with the following objectives: 1) monitor K soil test levels with straw removal and burning in the presence and absence of K fertilization; 2) measure K removal in straw and seed for various straw management and K fertilization regimes; 3) measure seed yield response to K fertilization and straw management.

High and low soil test K sites were planted to perennial ryegrass and tall fes-

cue, respectively. Treatments imposed on these sites were burn or bale straw management in combination with K fertilization. Potassium treatments (KCl) for each of the first two years were 36 lb/A K_2O and 100 lb/A for the third year, top-dressed in the early spring. Initial ammonium acetate-extractable K soil test levels for the high and low sites were 218 and 55 parts per million (ppm) for tall fescue and 164 and 78 ppm for perennial ryegrass, respectively. Straw yield, seed yield and soil test levels were measured annually at each site. Soils were sampled at the 0 to 1-inch and 0 to 6-inch depths. Tissue, soil and seed samples were analyzed for K.

Managing the Problem

Ash residue from burned straw and top-dress K fertilization concentrate K at the soil surface. Therefore, tests of the surface inch should reflect these K sources. Surface-inch soil test K values from K fertilized baled straw management treatments after the second harvest increased when compared to the no-K controls (Table 1). In contrast, surface-inch K soil tests from plots where straw was burned show no difference between fertility treatments. The most noticeable difference in surface-inch soil test K values was found when straw management was compared. Plots where straw was burned generally produced higher soil test K values in the

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surface inch compared to plots where straw was removed.

Differences in surface-inch K soil test values due to straw management are explained by the K contribution from the burned straw (Table 2). Between 54 and 178 lb/A K_2O was recycled by burning straw, exceeding the 36 lb K_2O/A fertilization applied the first two years. The difference between average surface-inch soil test K for baled and burned plots at the high K soil tall fescue site was 220 ppm. This results in approximately 90 lb K_2O/A recycled K through straw burning.

Grass seed yield response to K fertilization was small and irregular, even at the low soil test K sites. A yield increase trend existed at the low-K tall fescue site in 1989 and 1990. A significant yield increase from K fertilization was found at the low-K perennial ryegrass site in 1990.

Summary

This study confirmed grower observations that soil test K decreased rapidly when grass straw management changed from burning to baling. Seed yield in this study did not decrease as soil test K decreased at the high soil test K sites (initial soil test K > 150 ppm). However, seed yields tended to increase with K

Table 1. Soil test K after the second treatment year.

Crop	Soil test K rating	Soil depth, inches	Soil test K, ppm			
			Straw baled		Annual burn	
			+K	-K	+K	-K
Tall fescue	High	0-1	270	225	471	464
		0-6	266	225	305	317
Tall fescue	Low	0-1	60	57	89	88
		0-6	53	48	72	70
Perennial ryegrass	High	0-1	339	305	318	294
		0-6	192	173	182	193
Perennial ryegrass	Low	0-1	73	66	103	101
		0-6	56	59	83	70

fertilization at the low soil test K sites (initial soil test K < 100 ppm). These data substantiate Oregon State recommendations that K fertilization of grass for seed should begin when surface 6-inch soil test K values are below 100 ppm.

Tall fescue and perennial ryegrass are luxury consumers of K. High soil test K fields will produce grass straw with 1.5 to 2.5 percent K, while straw from low soil test K fields will be 0.5 to 0.7 percent K. Baling high K straw causes a proportional decrease in soil test K. Grass seed growers need to monitor soil test K as straw management changes from burning to baling, since straw harvest removes substantial quantities of K. ■

Table 2. Grass straw K uptake as affected by management.

Crop	Soil test K rating	Straw uptake of K_2O , lb/A			
		Straw baled		Annual burn	
		+K	-K	+K	-K
Tall fescue	High	241	220	164	178
Tall fescue	Low	54	31	75	64
Perennial ryegrass	High	70	59	90	79
Perennial ryegrass	Low	52	41	96	54



REMOVING straw in grass seed production removes large amounts of K.

Cotton Yield Enhancement Using Foliar-Applied Potassium Nitrate and PGR-IV

By Derrick M. Oosterhuis

Previous field research has confirmed the value of both foliar feeding with potassium nitrate (KNO_3) and the use of the plant growth regulator PGR-IV to improve cotton yields. Field research in 1991 and 1992 demonstrated the synergistic effect of foliar feeding with KNO_3 following applications of PGR-IV. The likely explanation is that the PGR-IV-treated cotton retained more fruit and the additional potassium (K) was needed to supply the nutrition of these added bolls.

RESEARCH at the University of Arkansas has shown a consistent and significant improvement in cotton yields and fiber quality from foliar feeding with KNO_3 . The introduction of faster-fruited varieties and the increased use of nitrogen (N) in crop management have led to widespread K deficiencies. These deficiencies can be corrected through soil applications, or possibly, by mid-season foliar applications of KNO_3 . Foliar sprays have the advantage of allowing producers to add K when tissue analysis indicates a pending shortage, thereby preventing yield losses.

Other research at the University of Arkansas has shown a consistent increase in cotton yields from applications of the growth regulator PGR-IV. Results indicate that foliar application of PGR-IV increases root growth of seedlings and also increases fruit retention. It was hypothesized that this increase in fruit retention should further increase the need for foliar-applied KNO_3 during the late season boll development period when K deficiencies are normally manifested.

Recent Studies

A field trial was conducted at the University of Arkansas Cotton Branch Station

in Marianna on a Captina silt loam to determine if the positive effects of PGR-IV on cotton yield could be further enhanced by foliar-applied KNO_3 . Treatments consisted of 1) a check with no added K or PGR-IV, 2) foliar-applied KNO_3 at 4 lb/A K_2O at 2, 4, 6 and 8 weeks after first flower, 3) PGR-IV at 4 oz/A applied at pinhead square and first flower, and 4) a combination of PGR-IV and foliar-applied KNO_3 (treatments 2 and 3 combined). Preplant fertilizer was applied at the rate of 54 lb N/A and 123 lb P_2O_5 /A with an additional sidedressing of 36 lb N/A at pinhead square. Initial soil analysis showed 258 lb K/A. The crop was grown using standard recommended practices for irrigated cotton in Arkansas. The foliar KNO_3 was applied in 10 gal/A water using a backpack sprayer.

Results

Boll weight, boll number and yield of seedcotton were significantly increased by foliar application of KNO_3 and PGR-IV (**Table 1**). Foliar KNO_3 increased yields by 54 lb/A (3.2 percent) and PGR-IV increased yield by 95 lb/A (5.6 percent). There was, however, an even greater increase from a combination of PGR-IV

Dr. Oosterhuis is Professor of Cotton Physiology, Dept. of Agronomy, University of Arkansas, Fayetteville.

Table 1. Effect of foliar treatments on seedcotton yield, boll weight and boll number.

Treatment	Boll weight, grams	Boll number, per 3 ft. row	Yield, lb/A	Yield incr., % of check
Check	4.50b	31.8c	1,682c	—
KNO ₃	4.73a	32.9bc	1,736b	3.2
PGR-IV	4.80a	33.9ab	1,777b	5.6
PGR-IV + KNO ₃	4.75a	34.9a	1,910a	13.6

Values within a column followed by the same letter are not significantly different ($p=0.05$).

and KNO₃ which increased yield by 228 lb/A (13.6 percent).

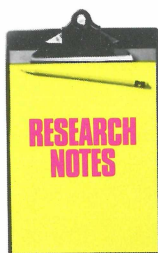
The increase in yield from the KNO₃ spray was consistent with our previous reports although not as large as usually experienced. The PGR-IV yield increase was also slightly less than previously reported. The 13.6 percent increase from the combined treatment was larger than the additive increase of the two individual treatments. This was probably because the PGR-IV treated plants retained more fruit,

and the additional K was needed to supply the nutrition of these added bolls.

A similar study conducted in 1992 confirmed the results of the 1991 investigations. The strong interactive effects of KNO₃ and PGR-IV were repeated, providing a seedcotton yield increase of 12.6 percent . . . very close to the magnitude of yield increase in the 1991 data.

Summary

Proper plant nutrition for optimal crop productivity in cotton requires that mineral deficiencies be avoided. The obvious question is whether the addition of other nutrients would also have been beneficial given the extra fruit retention and nutritional requirement in the PGR-IV treated plants. These preliminary data suggest that foliar feeding with KNO₃ following the application of the plant growth regulator PGR-IV enhances yield synergistically. This research is being continued to further evaluate the beneficial aspects of combining the use of PGR-IV and foliar fertilization as a management tool for cotton producers. ■



Minnesota

Eliminating Off-Farm Nitrogen: A Case Study

THIS STUDY was established on a Minnesota farm to evaluate options available to a farmer who wished to eliminate off-farm nitrogen (N) sources by utilizing only on-farm manure. Researchers evaluated three options: 1) Improving N use without changing crop and livestock enterprises substantially; 2) expanding livestock production; 3) increasing alfalfa production. The economics of each option were analyzed.

It was found that increasing alfalfa production would most likely meet the goal of eliminating purchased N fertilizers.

However, economic returns were not acceptable, primarily because of the loss of government payments, but also because of the problem of finding markets as hay production increased. Applying manure uniformly across the farmer's operation (three sites over an 11-mile area) was difficult because his management program was geared to meet goals other than making the best use of manure.

Researchers concluded that many of the decisions needed to manage fertilizers more efficiently . . . for both economic and environmental reasons . . . are farm-specific, not general in nature. ■

Source: Howard Person and Richard Levins. 1992. *J. Prod. Agric.*, Vol. 5, no. 4.

Suppression of Anthracnose on Soybeans with Potassium Fertilizer and Benomyl

By J.W. Sij, F.T. Turner and N.G. Whitney

Many studies have linked potassium (K) to suppression of plant diseases. Texas studies have found that anthracnose in soybeans is suppressed by adequate K nutrition.

STUDIES linking K with less disease in certain crops have stimulated interest in the benefits of K in plant disease protection. There have also been indications that increased K availability levels suppress soybean cyst nematode effects on the plant roots.

In the 1960s, researchers found that increasing K levels reduced the number of shrunken, moldy and discolored soybean seeds and resulted in increased seed weight, germination and yield. Researchers in Brazil during the mid-1970s reported that symptoms of pod and stem blight on soybean stems, pods and seeds were much less severe in plots receiving K. Additional studies on the effects of K on mold of soybean seeds indicated that as K fertilization levels increased, significantly fewer moldy seeds occurred, although seed yield was not affected.

Research reported in 1977 showed that K significantly reduced pod and stem blight effects on seed and reduced purple seed stain. Phosphorus (P) applications had no influence on the incidence of these diseases, and the action of K in reducing disease appeared to be independent of P.

A K fertilization study on soybeans in Ohio in 1982 showed that the number of moldy seeds was nearly always decreased by K fertilization. The researchers concluded that K fertilizer absorbed by plants possibly limited fungal growth after infection occurred.

Texas Studies

Anthracnose is considered to be one of the major diseases affecting soybeans in the South. Yield losses from this disease can be 20 percent or more. In recent years, the use of foliar fungicides has been instrumental in controlling certain soybean diseases and raising yields, particularly in the warm, humid southern U.S. soybean-production region. A study designed to evaluate K effects on anthracnose included the following objectives.

- To determine if anthracnose development in soybeans can be reduced by K fertilizer.
- To compare the control afforded by benomyl fungicide alone and in conjunction with various rates of K fertilizer.

The study was conducted at the Texas Agricultural Experiment Station at Beaumont on a Morey silt loam soil. Davis soybeans were planted from mid-May to late June during the 3-year study.

Soil sample analysis indicated that available K levels were in the low to medium range while P was medium to very high. The P and K fertilizers (triple superphosphate and potassium chloride) were applied at rates of 0, 60 and 120 lb P_2O_5/A and 0, 60, 120, 240, 360 and 480 lb K_2O/A and worked into the soil prior to planting. Split applications of fungicide

Dr. Sij is Professor of Soybean Physiology, Dr. Turner is Professor of Soil Science and Dr. Whitney is Associate Professor of Plant Pathology, Texas A&M University, Agricultural Research and Extension Center, Beaumont, TX.



PLANT AT RIGHT received adequate K, while stunted, deficient plant at left received no K.

(benomyl) were applied at the beginning of pod set and two weeks later.

Results

Year-to-year environmental conditions affected disease pressure. As expected, the foliar fungicide exerted its greatest effect on yield in high disease-pressure years. There was a significant year \times K level interaction with respect to anthracnose and yield. The first year was characterized by excellent growing conditions and low disease pressure, resulting in minimal effects of applied K on yield. But the 3-year average anthracnose disease

ratings decreased significantly with increased K level. Phosphorus had little influence on anthracnose development.

The effect of benomyl on anthracnose suppression was less pronounced as K levels increased. At 240 lb K_2O/A , benomyl provided no further disease reduction since the anthracnose rating was near zero. However, application of benomyl resulted in significant yield increases in the second and third years with high anthracnose pressure. The data indicated that the actions of K and benomyl are additive, although the mechanism of disease suppression between K and benomyl may be different.

Potassium increased yield significantly each year, regardless of disease pressure. Benomyl and K plus benomyl resulted in slightly higher yields than did K only, except at the highest level of K. Yields generally increased with increasing K up to 240 lb K_2O/A in both the benomyl-treated and untreated soybeans.

Summary

Over the years, soybean producers have had variable success with certain fungicides applied to soybeans. Disease pressure and environmental conditions at or during maturity play a major role in disease development. However, results of this study indicate that adequate K can also be a positive factor suppressing the incidence of anthracnose and other fungal diseases. ■



THE dark-colored mature soybeans on the right (which received no K) are infected with anthracnose.

Fertilization Effects on Soybean Sudden Death Syndrome

By D.D. Howard, A.Y. Chambers, P.W. Brawley and T.D. Bush

Sudden death syndrome (SDS) is a mid- to late-season, soil-borne soybean disease that can seriously diminish soybean yields. Tennessee research has shown that chloride (Cl) fertilization as potassium chloride (KCl) can significantly decrease SDS effects and improve yields.

SUDDEN death syndrome is a mid- to late-season, soil-borne soybean disease. The 1991 season was the most severe for SDS losses in Tennessee since the disease was diagnosed in soybeans in 1984.

The casual organism has been recently identified as *Fusarium solani*, a fungus found in many Tennessee soils. Severity of SDS has been observed to be favored by cool, wet weather, soils with high organic matter, the presence of the soybean cyst nematode, soils subject to water overflow and fields in rotation with corn. Planting soybeans after corn appears to increase the incidence and severity of SDS. Usually, healthy and vigorous soybeans are more affected by SDS than unthrifty, stressed beans.

Visual symptoms of SDS may first appear at flowering as yellow spots between leaf veins. The spots expand into yellow streaks which eventually die; only the major veins remain green. Severely diseased leaflets may drop, leaving the petioles attached to the plant. Root systems decay with brown vascular discoloration. Yield losses are due to leaf drop, flower and young pod abortion, pod drop and reduced seed size.

Until recently, the only control has been the use of varieties having tolerance to SDS. However, few varieties have resistance to SDS, stem canker and cyst nematode.

Research in the Great Plains, Northwest and Canadian Prairies has indicated that Cl applications can reduce or suppress the several fungal root and leaf diseases of wheat. Since diseases like take-all and SDS are both caused by soil-borne fungi, we thought Cl applications might also suppress infections in soybeans.

Tennessee Research

We evaluated the possible effect of Cl on SDS in soybeans. The original study was expanded to evaluate rotational effects with corn as well as Cl effects.

Studies were conducted at the Milan Experiment Station in 1990 on a Falaya silt loam soil with a history of SDS. The soil had a pH of 6.3 with 80 and 180 lb/A Mehlich I extractable phosphorus (P) and potassium (K), respectively.

Potassium rates of 120, 160 and 320 lb/A K_2O were applied in 1990. A rate of 80 lb/A K_2O as KCl was broadcast on the experimental area in the winter. On May 25, 40 and 80 lb/A K_2O as KCl and 80 lb/A K_2O as potassium sulphate (K_2SO_4) were broadcast on the plots. On June 26 a split application of 80 and 240 lb/A K_2O as KCl was applied to plots fertilized with 80 lb/A K_2O in the winter, giving a total K_2O rate of 160 and 320 lb/A.

The 1991 study was changed to a split-plot randomized complete block design with six replications. Main-plots were KCl rates, sub-plots time of application.

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Potassium rates were also changed to 50, 100, 150 and 200 lb/A K_2O as KCl applied at planting, plus a delayed application on July 1. The control was 150 lb/A K_2O applied as K_2SO_4 on the same dates.

Plots were rated for SDS incidence and severity prior to harvest and leaf drop in 1991, but not in 1990. Plots were harvested, and root systems were evaluated and rated for SDS symptoms both years.

Positive Effects

The 1990 data indicated yield benefits from late side-dressing of KCl compared with applying KCl or K_2SO_4 at planting (Table 1). Higher rates of sidedressed KCl (240 lb K_2O , 180 lb Cl/A) increased yield compared to a rate of 80 lb K_2O /A (60 lb Cl/A). Delayed ratings of root deterioration by SDS were inconclusive.

In 1991, KCl applications significantly lowered SDS severity based on leaf and root ratings compared with K applied as K_2SO_4 (Table 2). However, yields were unaffected by treatment. The SDS symptoms developed late in the season and may



SOYBEAN sudden death syndrome can cause serious yield losses. Chloride as part of potassium chloride fertilizer can decrease effects of the disease.

not have had sufficient time to affect yields as observed in 1990. The SDS leaf ratings, disease severity, and root ratings indicated that KCl applications were more effective than K_2SO_4 in reducing SDS symptoms. These observations indicate that Cl rather than K application was affecting SDS.

Benefits of delayed KCl application in 1990 may have been related to high rain fall (5.02 inches) and Cl leaching from KCl applications at planting.

Table 1. Effect of K rate, K source and Cl on soybean yield, 1990.

K_2O rate, lb/A		K Source	Cl rate, lb/A	Yield, bu/A
At planting	Side-dressed			
120	0	KCl	90	45
160	0	KCl	120	45
80	80	KCl	120	49
80	240	KCl	240	51
160	0	K_2SO_4	0	45
LSD (0.05)				2

Summary

Incidence and severity of SDS in soybeans were both reduced by Cl application as KCl. Yield effects varied in two years of study. Greatest yield benefit resulted when large amounts of precipitation occurred between planting and side-dressed KCl applications. More remains to be learned about the role of Cl in suppression of this disease, but results are encouraging. ■

Table 2. Effect of K rate, K source and Cl yield and SDS leaf and root ratings in soybeans, 1991.

K_2O rate, lb/A	K Source	Cl rate, lb/A	Yield, bu/A	SDS Leaf Symptoms		SDS root incidence ³
				Incidence, ¹ %	Disease severity, ² 0-9	
50	KCl	38	44	53	3.3	3.3
100	KCl	75	44	28	2.7	1.8
150	KCl	112	43	28	2.3	1.3
200	KCl	150	45	19	2.0	1.2
150	K_2SO_4	0	43	83	4.2	5.6
LSD (0.05)			NS	5	0.5	0.8

¹ Incidence—percent plants affected by SDS.

² Disease severity (ratings 0-9, 9 being most severe)

³ Number of plants/10 dug with affected roots.

Survey of Cotton Soils Shows Several Factors Related to Potassium

By C.C. Mitchell

A survey of 292 Alabama cotton fields in 1990 and 1991 found that potassium (K) soil tests in plow-layer samples did not reflect actual K status of cotton plants growing in those soils. The soil tests indicate that 60 percent of the fields were high or very high in K, while plant analysis indicated 61 percent of the samples were deficient in K at early bloom.

REPORTS from throughout the Cotton Belt have suggested that modern varieties and cultural practices may result in widespread K deficiencies in cotton. Impressive yield responses have been recorded from both surface and subsoil K applications on cotton land that tested medium to high for K in the plow layer, but low in the subsoil.

Soil test summaries from the Auburn University Soil Testing Laboratory indicate that plow-layer K in soil samples submitted for cotton has actually increased slightly over the past 25 years, while soil test phosphorus (P) has declined (**Figure 1**). However, rarely do cotton producers encounter P deficiencies, and plow-layer P soil tests are well correlated with cotton yield.

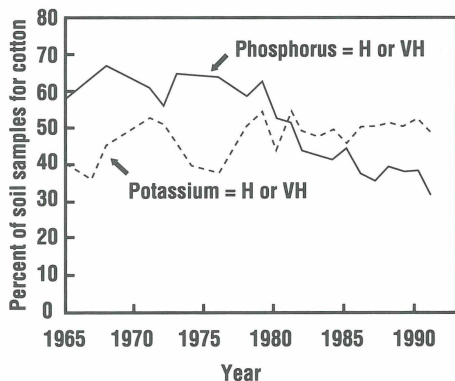


Figure 1. Long-term trends in soil test P and K in soil samples for cotton tested by the Auburn Soil Testing Laboratory.

Alabama Cotton Survey

Because of widespread concern about K nutrition of cotton and a need to identify other soil fertility factors which may limit cotton yields in Alabama, a statewide cotton survey was conducted during the 1990 and 1991 growing seasons. Leaf samples and plow-layer soil and subsoil samples were collected at early bloom from 292 randomly selected cotton fields in Alabama cotton-producing counties.

Nematode soil samples were also collected from the same fields in late September. The purposes of these samples were to 1) determine the fertility status of the topsoil and subsoil, 2) identify potential cotton nutritional problems based on leaf analysis, and 3) identify the extent of plant parasitic nematode problems in Alabama cotton.

Low K in Leaf Samples

Sixty-one percent of the cotton leaf samples were rated below sufficiency for K (less than 1.5 percent K at early bloom), Table 1. The percentage was much higher in the coarse-textured Lower Coastal Plain soils and much lower in the finer textured soils of the Limestone Valleys. This is the most dramatic observation from the survey. Plow-layer soil samples (Table 1) and long-term trends in soil test values from the Auburn Soil Testing Laboratory (**Figure 1**) give no indication of this situation.

Dr. Mitchell is Extension Agronomist-Soil Fertility, Auburn University, AL.



POTASSIUM deficiency is shown in this cotton field on Coastal Plain soil in Alabama. Traditional methods of soil testing and plant analysis may need to be modified for today's varieties and yield goals.

Low Subsoil K

Soil tests from the Alabama survey indicated that 60 percent of the fields were

high or very high in plow-layer K, which is very close to the trend for K in plow-layer samples tested by the Auburn Soil Testing

Table 1. Selected analyses and observations from Alabama cotton fields.

Observation	Limestone Valley (n=135)	Upper Coastal Plain (n=57)	Lower Coastal Plain (n=100)	Alabama average
----- % of samples -----				
Leaf samples at early bloom				
Leaf N < 3.50%	0	1	3	2
Leaf N > 4.50%	68	60	54	61
Leaf P < 0.30%	20	4	1	10
Leaf K < 1.50%	44	68	80	61
Leaf K > 3.00%	0	0	0	0
Soil samples				
pH < 5.0 in plow layer	2	2	4	3
pH < 5.0 in subsoil	8	16	22	14
K = low in plow layer ¹	3	0	7	3
K = low in subsoil	25	30	32	29
K = high in plow layer ¹	74	70	34	60
K = high in subsoil	27	9	18	19
Soil characteristics				
Depth to B horizon < 12 inches	98	90	91	93
Traffic pan within 12 inches of surface	19	63	41	44

¹Based upon calibration for Alabama Soils in Alabama Experiment Station, Cir. 251 (1981).

Laboratory (Figure 1). However, analyses of subsoil samples indicate that 80 percent of the survey fields were low to medium in K. Potassium doesn't move downward as rapidly as once thought—even in sandy soils. Long-term soil fertility studies in Alabama, one continued since 1911 and six since 1929, indicate considerable K accumulation in surface soil horizons.

Traffic Pans in Coastal Plain Soils

A characteristic of many coarse-textured Coastal Plain soils is the tendency to develop traffic pans at the depth of plowing where the coarser surface soil is mixed with the finer textured subsoil. **Sixty-three percent of the fields in the Upper Coastal Plain of Alabama had traffic pans within 12 inches of the surface; 41 percent of the Lower Coastal**

(continued on next page)

Plain soils had traffic pans. During the survey, we found that many Lower Coastal Plain growers routinely practice in-row subsoiling at or before planting to fracture a traffic pan, whereas most Upper Coastal Plain cotton growers do not practice subsoiling.

Excessive N and Subsoil pH

Excessive nitrogen (N, > 4.5 percent) in 61 percent of the leaf samples at early bloom may indicate that a potential exists for excessive vegetative growth later in the season if weather conditions are favorable. Excessive N could also aggravate K uptake. Subsoil pH was below 5.0 in 22 percent of the Lower Coastal Plain fields and 16 percent of the Upper Coastal Plain fields. This could also restrict root growth into the subsoil.

Reniform and Root Knot Nematodes

Reniform and root knot nematodes have been shown to reduce K uptake. These two pests were found extensively in Coastal Plain soils, but rarely together in the same field. Root knot nematodes were found in 57 percent of the Lower Coastal Plain fields and in 13 percent of the Upper Coastal Plain fields. Only 5 percent of the Limestone Valley cotton fields had root knot nematodes present. Reniform nematodes, which may reduce K uptake more significantly than root knot, were found in 40 percent of the Upper Coastal Plain fields, in 9 percent of the Lower Coastal Plain fields and in only 3 percent of the Limestone Valley fields. Parasitic nematodes cannot be ignored as a factor in the increasing concerns about K nutrition of cotton in the Southeast.

Summary

Potassium accumulation by surface soil horizons and low subsoil K, the presence of root-restricting traffic pans in Coastal Plain soils, reniform and root knot nematodes, extremely acid subsoils, and excessive N may all play a part in low leaf

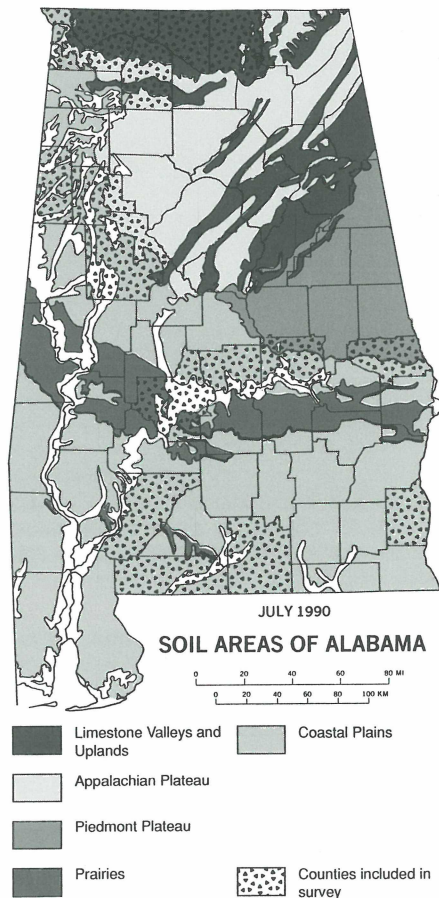


Figure 2. Alabama cotton-producing counties sampled during 1990 and 1991 growing seasons. Counties were grouped based upon the soil physiographic region as 1) Limestone Valley, 2) Upper Coastal Plain or 3) Lower Coastal Plain.

K observed during this survey and in K problems observed in other Mid-South cotton fields. Earlier maturing and higher yielding varieties may also stress the root system to take up enough K during a shorter period of growth. Traditional, plow-layer soil tests for K may not be enough to adequately predict the need for additional K fertilization, and leaf K sufficiency levels currently used may need adjustment for the newer varieties and high yields of cotton. ■

Potassium–Water Relationships in Winegrape Production

By Mark A. Matthews and Mike M. Anderson

Winegrape production is dependent on ample availability of both potassium (K) and water. Management of these two factors becomes especially critical beginning with fruit ripening late in the season because the fruit itself is a large K sink. Research in the North Coast region of California is studying the interrelationship between K fertilization and irrigation management.

GROWERS easily recognize yellowing between the veins and browning of leaf edges as symptoms of K deficiency in grapes. Often, deficiency symptoms appear late in the season, after onset of fruit ripening (veraison). This is well after the usual bloomtime sampling of leaf petioles routinely used for determining vine nutrient status and fertilizer needs. In severe cases, vines may lose a large portion of their leaves, causing delayed fruit ripening. During the recent drought years in California, reports of K deficiency symptoms have increased. This resurrects questions regarding the identification of K deficiencies and the K requirements for production and winegrape quality.

Potassium Deficiency

What determines whether a vine is adequately supplied with K? Grapevine K status is determined by both plant and soil factors, but only soil factors have received researchers' attention. Differences among viticultural regions or vineyards in either set of factors may be important in identifying and correcting K deficiencies. Potassium deficiencies occur more often on sandy soils than on soils with moderate to high clay content. Accordingly, much of the research used to establish criteria for K requirements of grapevines has been conducted on light soils prone to K deficiency, such as in California's San Joaquin Valley. Because the drought seemed to be

correlated with increased reports of K deficiency in vineyards on heavier soils in the North Coast region of California, we have been investigating possible regional differences in soil, water and vine characteristics that may be important in vineyard K nutrition. We have found that selection of rootstock and management of soil water content can be important factors.

Potassium Fertilization

When K fertilizer is applied to the soil to increase K supply to vine roots, part of the added K increases the concentration of K in the soil solution, part is adsorbed onto the exchange sites of clay particles and part may be incorporated into nonexchangeable (fixed) forms that return slowly to the soil solution. Thus, the propensity of some soils to replenish the K taken out of the soil solution by vine roots can be low, leading to a decreasing availability of K as the season progresses. This may be one factor contributing to late season K deficiency symptoms on heavier soils. Also, soils with higher fractions of K-fixing clays like vermiculite or with high exchangeable magnesium (Mg) may require higher rates of fertilizer K than indicated by recommendations generated from research on lighter San Joaquin Valley soils in order to get the same increase in K concentration in the soil solution and in K uptake by the vines.

(continued on next page)

Dr. Matthews is Associate Professor and Mr. Anderson is Research Associate, Dept. of Viticulture & Enology, University of California, Davis.

Potassium Availability and Water

Potassium availability is sensitive to soil water conditions. When irrigation regimes do not resupply the water extracted by the vines and as soil water content decreases, certain clays, e.g., montmorillonite, contract and trap K ions in the interlayers of the clay lattice. This can contribute to late season K deficiency in several ways. On soils with significant amounts of contracting (i.e., shrink-swell) clays, K deficiencies may not occur early in the season when soil water contents are high from winter rains. However, if the soil becomes increasingly dry, K availability diminishes. Deficiency symptoms then develop, especially later in the season when full canopies extract soil water more rapidly than early in the season.

Potassium deficiency symptoms may appear after veraison in vineyards that might produce adequate (or nearly so) tissue K concentrations from samples taken at bloom. Where the drought has decreased the soil water supply available at the beginning of the season, a failure to compensate with more irrigation water can lead to greater soil water deficits than vines had experienced in wetter years. The drier soil again diminishes K availability, inducing K deficiencies in vineyards that previously showed no symptoms. For similar reasons, deficit irrigation for canopy management and to control yield and fruit composition is another potential factor in the appearance of late season K deficiencies.

Recent Studies

Recently, a field study was conducted in a commercial North Coast vineyard of Pinot noir (St. George rootstock) on a clay loam soil. It was an initial evaluation of the role of soil water status in vine K uptake on heavier soils. Treatments of potassium sulphate (K_2SO_4) at a rate of 8 lb/vine were applied to the soil beneath each drip irrigation emitter. Some vines received the standard 10 gal of water/vine/week and others received supplemental irrigation at 40 gal/vine/week.

The vineyard exhibited low available soil K, approximately 130 parts per million (ppm) exchangeable K and low petiole K initially (less than 1 percent of bloomtime dry weight). Petiole K decreased throughout the season for untreated vines to about 0.2 percent K at harvest (Table 1). Maintenance of high soil water content under supplemental irrigation increased the availability of K to both K-treated and untreated vines. For untreated vines, petiole K was greater than 0.5 percent at harvest. For K-treated vines that received supplemental irrigation, petiole K actually **increased** during the season. The large differences (several-fold) in vine K status during fruit ripening were associated with smaller differences in juice K and no significant differences in sugar accumulation, pH or acidity of the harvested fruit. Thus, the soil water content during fruit ripening can be an important factor in maintaining canopy K status.

Table 1. Potassium content of petioles and fruit for different K and irrigation treatments for the 1990 season.

	Petiole K, % dry wt.		Juice K, ppm
	Bloom	Harvest	
Standard irrigation			
– K	0.71 ± 0.04	0.24 ± 0.02	1,550 ± 48
+ K	0.82 ± 0.11	0.58 ± 0.12	1,691 ± 134
Supplemental irrigation			
– K	0.80 ± 0.11	0.51 ± 0.06	1,673 ± 55
+ K	0.90 ± 0.06	1.23 ± 0.12	1,759 ± 47

\pm standard error.

Plant factors of vine K nutrition include rootstock and scion variety and crop load. Because the fruit constitutes a large K sink, the requirement for K increases later in the season. Scion varieties differ in their requirements for some nutrients, but little research on K nutrition has been conducted on vinegrape varieties. The criteria for K sufficiency in bloomtime petioles were derived from extensive research with Thompson Seedless table grapes. It is not clear whether these criteria are accurate



POTASSIUM deficiency appears on grape leaves and clusters in a rootstock research study.

for winegrape varieties. There is increasing evidence from studies around the world that rootstocks differ in their capacity for nutrient (including K) uptake and that there may be specific rootstock-scion interactions that contribute to vine growth and productivity.

In another field study, the potential to use rootstocks to combat low soil K availability was pursued in an established rootstock trial where vines were exhibiting K deficiency symptoms. The rootstocks 110R, 5C, AxR#1, St. George, and 1202 were investigated to determine whether they caused differences in the K status, fruitfulness and yield of Chardonnay vines growing on a soil with low K availability. Over two seasons the K in bloom petioles was more than two times greater in 5C than 110R. One year after K fertilizer was applied (8 lb K_2SO_4 /vine), yield and clusters/vine increased (up to 60

percent) for all rootstocks except 5C, **Table 2**. The high yield, high petiole K and lack of a yield response to applied K on vines on 5C suggest that 5C is more effective at absorbing K from this soil. The results show that there are significant differences among rootstocks in K uptake and in the productivity of the scion at a given petiole K status.

Summary

For existing suspect vineyards, sampling and analysis of vineyard K status and soil water status at or after veraison may be important tools for management decisions. For future plantings, more knowledge of the physiological differences among varieties and rootstocks is needed. Because rootstocks arise from several different species, the probability of significant differences in several aspects of growth and nutrition is high.

We anticipate that assays for K status, including the new and sensitive putrescine screening technique, will be tailored to specific varieties and variety-rootstock combinations as more is learned about the nutritional requirements of winegrape varieties and rootstocks. ■

Table 2. Potassium affects yield of Chardonnay grown on different rootstocks for the 1990 season.

Rootstock	Yield, tons/A		Clusters/vine	
	+K	-K	+K	-K
110R	5.9 ± 0.2	3.6 ± 0.3	66 ± 4	45 ± 3
5C	5.3 ± 0.7	5.1 ± 0.4	59 ± 7	58 ± 5
AxR#1	6.2 ± 0.5	4.5 ± 0.3	68 ± 3	56 ± 5
St. George	3.1 ± 0.3	2.3 ± 0.3	42 ± 4	32 ± 2
1202	6.3 ± 0.4	4.9 ± 0.4	69 ± 4	55 ± 5

± standard error.

Potassium Fertilization Influences Cotton Dry Matter and Yield

By W.T. Pettigrew and W.R. Meredith, Jr.

Potassium (K) deficiency decreased fiber maturity by causing less cellulose to be deposited in the fiber secondary wall. Potassium fertilization increased lint yields due to more lint turn-out (percent lint) and produced a higher micronaire.

POTASSIUM deficiency of cotton has been reported throughout the Cotton Belt. Our study investigated the genotypic variability in lint yield and fiber quality as affected by nitrogen (N) and K fertilization.

Mississippi Study

A field study was conducted on eight genotypes representing a range of maturity and regional adaptations; DES 119, DPL 5415, HS 26, MD 51 ne, PeeDee 3, STV 453, STV LA 825, and STV 887. All plots received a preplant application of 100 lb/A N. A sidedress application of 36 lb/A N was applied to half of the plots. Potassium was surface-applied at zero and 120 lb/A K₂O. The experimental design was a split-split plot with N levels as the main plot, K levels as the sub plots and genotypes as the sub-sub plots.

Results

Potassium fertilization affected lint yield and fiber maturity in three years of the study. Also, K fertilization reduced the ratings for white speck or dead fiber (Table 1).

There was no K x genotype interaction detected for any of the yield or fiber quality components. In addition, N did not interact with K to affect any parameter.

Plant growth was altered by K deficiency (Table 2). Low K plants had an 18

Table 1. Effects of K fertilization on fiber characteristics and lint yield.

Potassium rate, lb/A K ₂ O	Fiber maturity, %	White speck (dead fiber) ¹	Lint yield, lb/A
0	76.9	3.06	1,042
120	80.3	2.72**	1,139*

¹White speck rated 1 (good) to 4 (worst).

* and ** denote significance.

percent lower leaf area index (LAI) and a 12 percent lower stem weight. However, the K deficiency increased the specific leaf weight (SLW) by 16 percent. Supplemental N caused DES 119 to allocate more dry matter to vegetative growth. MD 51 ne did not alter dry matter partitioning in response to additional N. Potassium deficiency produced a 7 percent decrease in fiber micronaire, but fiber perimeter was not influenced by K fertilization.

The K deficiency resulted in less cellulose being deposited in the secondary wall of the fiber, which caused the decrease in fiber maturity and micronaire. The data from this study imply that all cotton genotypes benefit from higher K availability with higher yield and fiber quality. ■

Table 2. Effect of K deficiency on cotton.

x Reduced leaf area index (LAI) 18 percent.
x Reduced fiber maturity 4 percent.
x Reduced lint turn-out (percent lint) 2 percent.
x Reduced yield 105 lb/A.
x Reduced fiber micronaire 7 percent.
x Increased specific leaf weight 16 percent.
x Reduced stem weight by 12 percent.

Dr. Pettigrew is Plant Physiologist and Dr. Meredith is Research Geneticist with USDA-ARS, Cotton Physiology and Genetics, Stoneville, MS.

Environotes from TVA

By John E. Culp

TVA engineers and regional managers are constantly asked to provide information on secondary containment methods and structures. Major concerns are relative costs of possible containment construction materials.

TVA staff provide such information and emphasize the need to manage a containment system properly to assure that it operates as it should. Installment and management of a system must be accompanied by a commitment of all plant personnel to protect the environment.

Lessons from ESAs

Managers face a variety of decisions in establishing an environmentally sound operation. The starting point is an assessment of existing conditions, done through an environmental site assessment (ESA).

Findings in an ESA can contribute a great deal of information to help a manager plan for and invest in modernizing a facility to bring it into regulatory compliance. Correcting the problems noted in an ESA can substantially reduce environmental liabilities and assure that releases from the plant operation do not contaminate surface and groundwater.

Retailer Concerns

TVA's regional managers work closely with the agricultural retailers across the country. Their objective is to introduce TVA-developed environmental technologies and assist the retailers in using that technology.

Here are some concerns retailers are expressing:

- In some areas, such as the Corn Belt, the main issue is remediation. Retailers are wondering what the states' rules will be—will they have to clean up any sites? Will they be able to transfer their prop-

erty? Will there be any value remaining in their property?

- Containment is an important issue in many states. It has been accepted as a way of doing business by many retailers. Where there are no containment regulations—or discussions about regulations—little is being done. Few doubt, however, that proper containment will be a standard of agricultural chemical operations in the future.
- It is difficult for many retailers to keep track of all the rules and regulations that apply to them. Reporting, permitting, and recordkeeping require a great deal of time and study of regulations. Many state regulations are not well known, but the burden is on the retailer to know them. Some dealers are hiring consultants to keep track of regulatory requirements. Others have an “in-house” person dedicated to environmental reporting issues.

Large Tank Containment

TVA engineers have worked with several retailers in large tank containment. We define large tanks as those with a volume greater than 100,000 gallons. Many solutions for containing large tanks have been proposed—and many meet state regulations. Bladders have been used in place of dikes. Steel false bottoms can be used in some large tanks for detection. Some states will allow automatic electronic liquid level monitoring as a form of leak detection. Some states have permeability requirements which prohibit use of natural clay soils or clay liners. Other states permitting higher permeability will probably have many earthen dikes. Regulations vary widely, as do solutions to problems. ■

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Society Doesn't Appreciate Agriculture

How does the North American public view agriculture? What do people want from it?

Inexpensive food. They **get it** but don't realize it. A yard man charged \$1.00 to mow my lawn in the 1930s. Now it costs \$40. At that rate of increase, the dozen eggs I paid 30 cents for would cost me \$12 today.

Safe food. Unsafe food results from mishandling **after** it leaves the farm.

Environmental purity. Good farmers are kinder to the environment today than at any other time in history.

Farmers supply quality food at low prices, and are responsible stewards of soil and water resources. Yet, society doesn't understand farming and is sometimes critical of today's marvelous, high-tech agriculture.

The public will pay the price for items it considers essential. Consider the costs residents face for waste disposal in a major city, for example:

\$125 to landfill one ton of garbage
\$400 to landfill one ton of sewage sludge
\$900 to landfill one ton of incinerated sewage

And what does a farmer get for his corn—about \$110 per ton!

Are people more concerned about garbage than corn? Is corn too cheap? Do farmers get the income their skill and risks deserve? Does agriculture do a poor job of keeping the public informed?

J. Fielding Reed

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