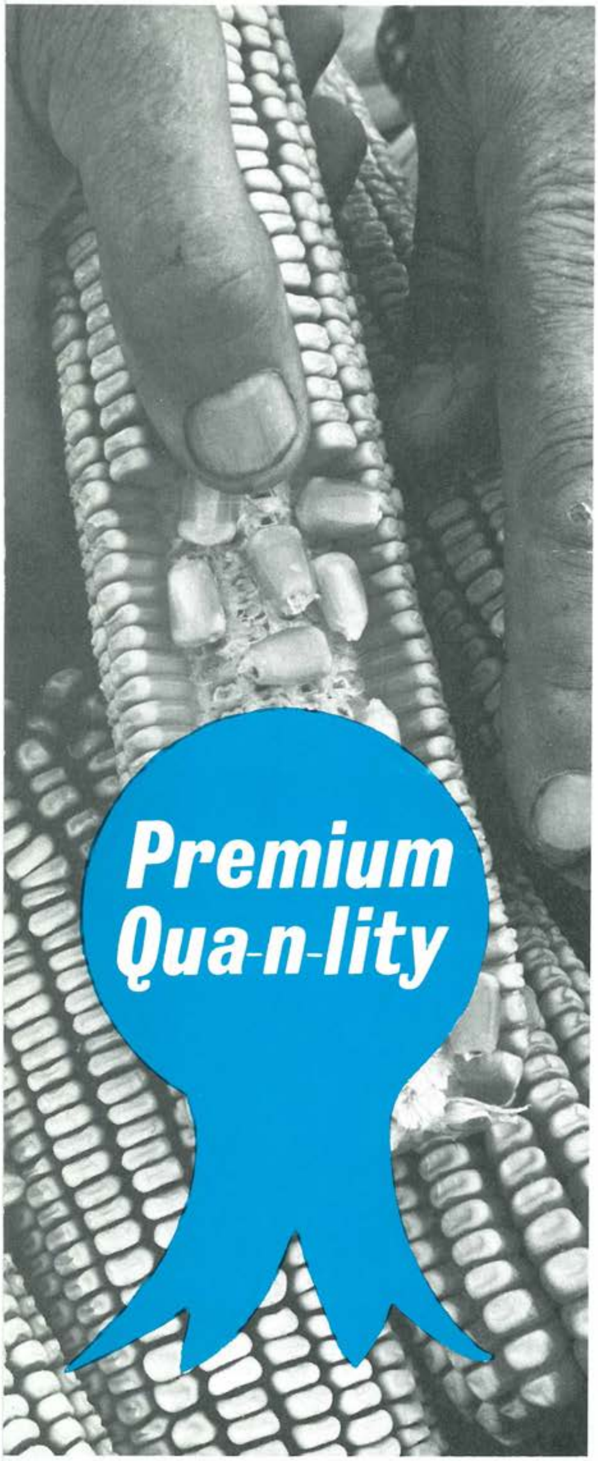
Better Crops
WITH PLANT FOOD
Number 1 — 1968 25 Cents

With K:

BUILD CROP QUA-N-LITY

per plant, per acre



WHAT IS QUA-N-LITY?

IT'S WHAT HAPPENS to a crop when steps taken to increase its yield also increase its quality.

This is happening more and more with today's high-yield agriculture. Fertilization to improve **quantity** is also improving **quality**—to get qua-n-lity.

In this special issue of BETTER CROPS, 14 scientists discuss the role of **POTASSIUM (K)** in crop quality—how it helps build premium crops.

Potassium **(K)** has been called many things by many scientists:

- **"The meat and potatoes food that makes plants grow healthy."**
- **"The jack of all trades in plant life."**
- **"A chemical traffic policeman."**
- **"The workhorse of agriculture."**
- **"An essential co-factor . . . involving the formation and utilization of the activated acyls either during the process of oxydative or glycolytic phosphorylation or during the inverse process of substrate activation by means of ATP."**
- **And it has been called "the quality nutrient."**

Step by careful step, research has shown how potassium helps many enzyme actions of plants . . . helps the plant convert energy into food-forming action (photosynthesis) . . . helps increase protein content of plants . . . helps translocate vital sugars and starch in the plant system . . . etc.

How do these actions affect extra alfalfa cuttings . . . or the looks and taste of canned peaches . . . or the market appeal of potato chips . . . or the smooth plumpness of rice grain . . . or the health of soybeans . . . or the feed value of corn grain and silage . . . or pineapple flesh . . . or the ripening of grapes . . . or banana maturity and flavor . . . or the acid content of lemons . . . or the sugar content of sugarcane . . . or cotton strength . . . or turf hardiness?

This issue gives some up-to-date answers. Issue chairmen were Dr. W. L. Nelson and Dr. R. P. Humbert of the Potash Institute.

The Editor

Better Crops WITH PLANT FOOD

The Whole Truth—Not Selected Truth

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A Special Issue On Potassium As A Crop Quality Builder . . .

Potassium Builds SOYBEAN QUALITY

★ Helps reduce number of shrunken, moldy, discolored seed.

★ Helps boost seed weight and germination rate.

★ Helps reduce moisture buildup in seed.

A. J. OHLROGGE
PURDUE UNIVERSITY

MOST SOYBEAN growers have experienced the effects of late summer droughts, causing soybeans no larger than field peas. The effects of fertilization are more difficult to find. Fertilizer effect on size can easily be demonstrated in the greenhouse. **Table 1** shows how much manure and micronutrients influenced seed size.

Similar differences are occasionally found in field experiments where severe nutrient deficiencies occurring during the filling period are corrected by fertilization.

FOR SEED QUALITY—Many seed characteristics can contribute to poor seed quality: shrivelling, helium color bleeding, greenness, purple blotch, etc. Frosting of immature plants can severely lower seed quality.

Immaturity may be traced to late planting of long season varieties or severe droughts followed by warm, wet weather causing secondary growth. Nutrient imbalances and certain disease infections contribute to poor seed quality.

Table 1. Both a micronutrient mixture and manure influenced seed size (gms per 100 seeds) on Sharkey Clay in Greenhouse Exp.

Manure Levels	Micronutrient Levels 0	1	2
0	15.4	17.4	20.2
1	16.9	19.7	19.6
2	19.3	18.3	19.8

LSD (5%) 0.42 gms.
(1%) 0.57 gms.

Purdue M.S. Thesis—R. P. Norton.

Very little data can be found on changes in seed quality at the 40 to 50 bushels per acre yield level. They are easy to find at low yield levels. **Tables 2 and 3** show the influence of potash on soybean quality in North Carolina and Purdue trials.

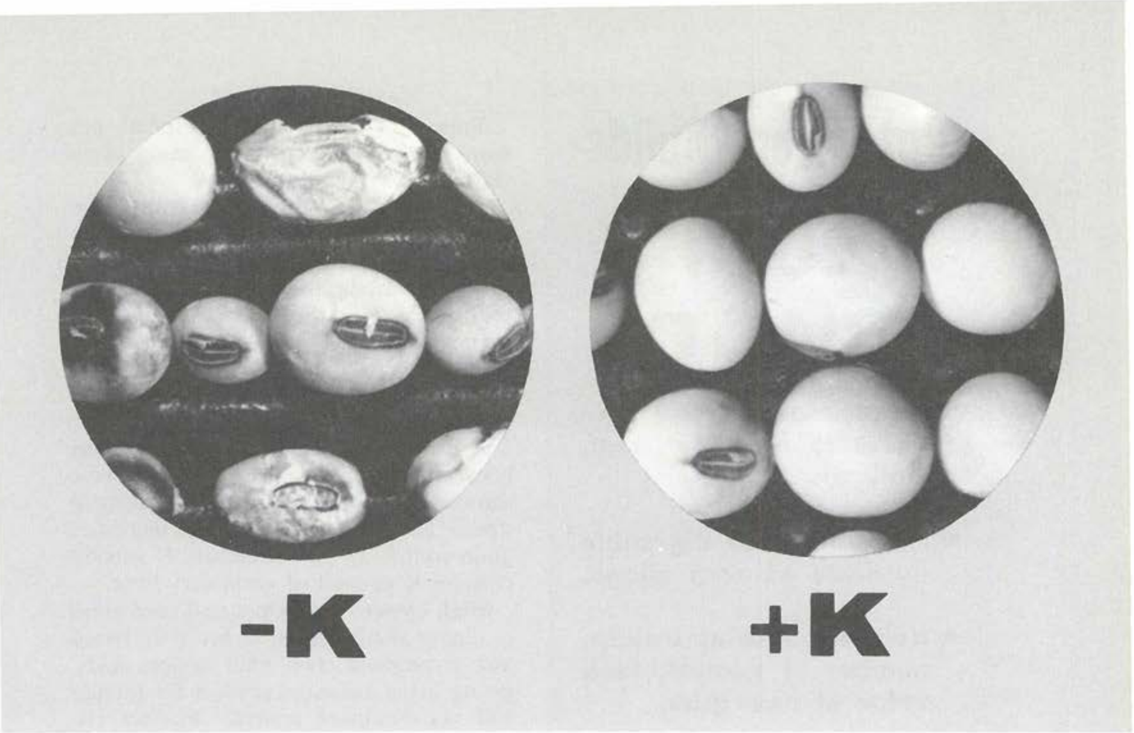
Note how few shrunken, shriveled, moldy, or discolored seed North Carolina's potash-treated plots yielded—34% less than no-potash plots. Note how much less moisture, less damage, and more germination Purdue's fertilizer-treated beans showed beside no-fertilizer plots.

Although the Indiana yields were much higher than the North Carolina trials, the no-fertilizer plots still showed severe potash hunger signs, though not as severe as the North Carolina deficiency. Such striking differences in seed quality will seldom, if ever, be found at the 40 bushel per acre level.

If it is found, it is almost always associated with soybean diseases that attack the plant late in the season. The disease may attack the roots, stems, conducting tissue or the leaves, thereby interfering either with the production of photosynthates, their transport to the developing seed, or the conversion of photosynthates into storage products within the seed.

SEED COMPOSITION—Protein and oil account for 60-70% of the dry weight of the bean. Changes in their content are easy to find in the literature when yield levels are very low or the crop is grown in the greenhouse.

But changes at the 50 bushel level are



HELPS INSURE HEALTHY BEANS

difficult to find in the literature. Only recently has research begun at this level. At high yield levels, combinations of factors influence seed composition more than individual factors. This makes research more complex.

Environment little affects the mineral composition of soybeans, with one exception. While phosphorus, potassium, calcium, etc. contents are fairly constant, the molybdenum concentration of the seed will vary three or four-fold. In fact, molybdenum seed concentrations seem to indicate the amount that was available to the crop.

THE END

TABLE 2. EFFECT OF POTASH ON OGDEN VARIETY—NORTH CAROLINA *

K_2O	Yield	Shrunken, shriveled, moldy or discolored seed	Weight per 100 seeds
lbs/A	bu/A	%	gm
0	7	37	11.2
120	27	3	14.5

* P applied to both plots—Low K Soil.

TABLE 3. EFFECT OF FERTILIZER ON SOYBEAN QUALITY—PURDUE

	Yield	% H_2O	Commercially damaged or purple blotched seed	Germination
	bu/A	Oct. 3	%	%
No fertilizer	20.2	58.6	17.3	82
400 lb/A 0-10-20	32.9	12.3	2.9	93

Potassium Builds CORN QUALITY

★ Helps make strong corn tissue to face root, leaf, stalk diseases.

★ Helps increase digestible nutrients of corn silage.

★ Helps increase ear weight, number of kernels, feed value of corn grain.

R. D. MUNSON
ST. PAUL, MINNESOTA

WHEN PROPERLY teamed with other elements, potassium means MORE plus BETTER corn. By "better" we mean better quality corn.

K & CORN GRAIN—Low-potassium corn gives unfilled, chaffy, flexible ears of low bushel weight. K influences the rate starch is laid down in developing kernels. With adequate N and P, K raises the grain starch to protein ratio which may reduce percent protein slightly. But Michigan reports some cases of K increasing grain protein nearly 40%—8.38% to 11.56%.

Garrard found K increasing the number of kernels 24% per ear, boosting ear weight by a 2.5 factor, and improving shelling percentage 7.6%. Based on grain weight, No. 2 corn with 20,000 ear-bearing stalks on this soil would have produced this estimated yield:

Without K	With K
84.4 bu/A	230 bu/A

Potassium helps the corn plant put more nitrogen to work increasing grain yields.

K Content Of Corn Grain. Corn grain usually contains about 0.35% K, low for some classes of livestock. Missouri found sheep needing up to 0.55% K in dry matter or 0.5% K in the ration. About 1% K produced best steer gains per pound of feed. And Iowa suggests 1.0 to 1.2% K may be needed for top feed efficiency and weight gains of growing pigs.

A positive relationship appears to exist between protein and K. Basic studies have shown K helping animals to withstand stress. Though fertilization has increased grain content by .1% K, added K usually changes K content of grain very little.

High Lysine Corn. Opaque-2 corn grain is higher than normal hybrids in lysine and tryptophan, two vital amino acids, giving better balanced protein for human and non-ruminant animals. Pioneer Hi-Bred Corn research shows that Opaque-2 grain also is higher in potassium.

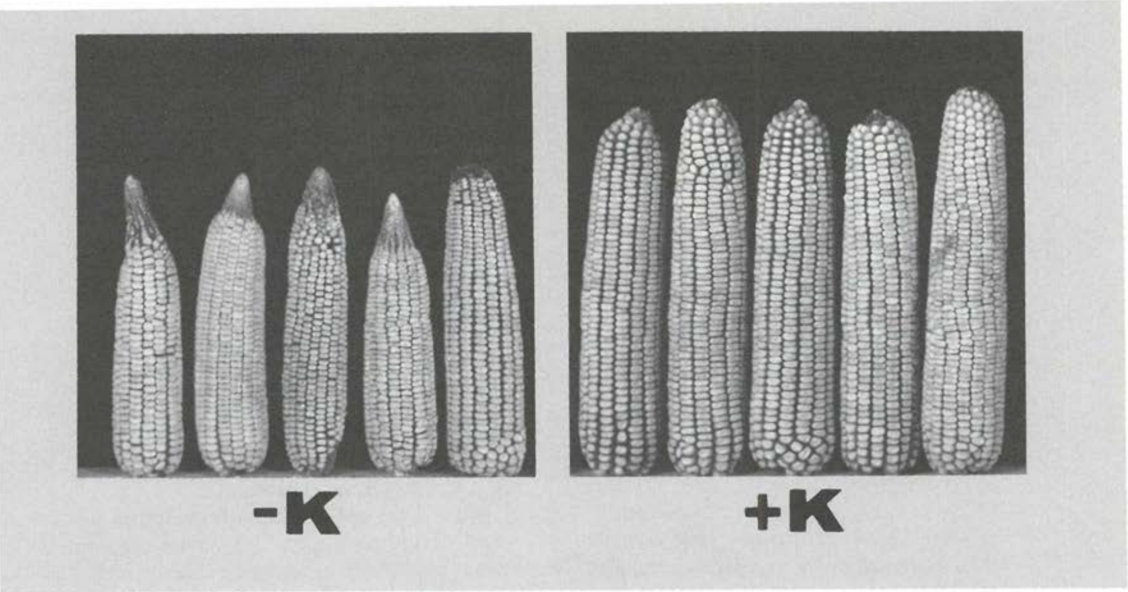
	Trans-lucent	Opaque-2	% Increase
	%K	%K	
Kernels	0.38	0.53	39.5
Embryos	1.94	2.18	12.4
Endosperm	0.09	0.15	67.0

The mechanism for accumulating K in grain appears to be genetically controlled. The higher K could improve mineral balance for some animals, an added quality feature of high lysine corn. Illinois researchers found normal corn yielding 144 bu., high lysine corn 133 bu. per acre.

Does K fertilization change the proportion of amino acid in grain of normal hybrids? We know it affects protein configuration. Scientists are working on this possible quality influence of K.

K & CORN SILAGE—Corn silage is primarily an energy feed, though protein content is important. Some workers believe silage quality depends on corn maturity at harvest. They suggest making silage at late dent stage of grain development.

But there are more quality factors than



FOR CORN QUALITY	−K	+K	% Increase
Potash Treatment, Lb. K_2O/A	0	100	
Average Yield, Bu/A	75.1	127.3*	69.5
Average Stand, Stalks/A	18,508	19,443	5.0
Shelling percent	83.1	85.1	2.4
Kernel Weight, Grams/Kernel	0.203	0.269	32.5
No. of Kernels/Ear	490	626	27.8
Ear Weight, Grain/Grams	100	168	68.0
Cob/Grams	21	30	42.8
Bushel Weight, Lb./Bu.	54.7	57.3	4.8

* Average Several Planting Dates. Later Planting Dates Lowered Average Yield.
Stanley A. Barber, Department of Agronomy, Purdue University.

maturity. High grain content usually means better silage quality and feeding value. Potassium plays a role in this quality:

- **K** raises grain to stalk ratio 10% on some hybrids, boosting digestible nutrients and digestibility of the silage.
- **K** increases ear weight 50% or more, even on medium K soils.
- **K** increases the fermentable carbohydrates leading to increased lactic acid formation, Wisconsin work shows. When carbohydrates are adequate, the lactic acid forming bacteria use little protein, increasing the silage content.
- **K** can double carotene content of silage when combined right with NP, Wisconsin work shows. Corn with enough K had ripe ears on green stalks.
- **K** not only increases yields but reduces dry matter lost during ensiling process:

Treatments	Fermentation Losses
	%
NP	6.8
NPK	2.1

- K increases total crude protein content of silage, when combined right with NP. If nutrients are applied in right BALANCE, the K usually increases true and soluble protein and decreases non-protein N. If an IMBALANCE occurs, K may actually increase the non-protein fraction of N in silage.

We must not forget the relative influence of K on the TDN and crude protein of silage because research has shown this ratio to be important in feeding trials.

Big Plus For K. Yes, K does play a vital role in corn quality—influencing carbohydrate production, N utilization, and organic acid content. But the big plus may still be what potassium does for grain and silage *quantity*.

THE END

Potassium Builds ALFALFA QUALITY

★ Helps insure more frequently cut, digestible alfalfa.

★ Helps alfalfa dominate weeds in older stands, grass in mixtures.

★ Helps reduce leafhopper damage.

MILO B. TESAR
MICHIGAN STATE UNIVERSITY

POTASSIUM INFLUENCES alfalfa quality, but does it more indirectly than nitrogen increases protein in grass, for example.

BETTER FEEDING VALUE—Adequate potassium encourages alfalfa to give a real yield bonus from that extra cutting. Look at FIGURE 1. With high potassium, an extra cutting gave an extra ton of alfalfa yearly on a sandy loam in Michigan.

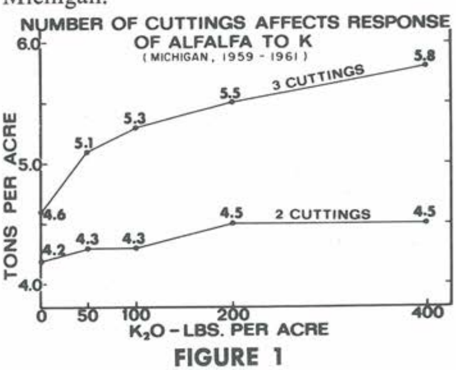


FIGURE 1

Recently, *in vitro* tests have been developed to measure digestibility or dry matter disappearance of small amounts of ground plant material, using rumen inoculem for digestion.

Such a Michigan test showed the feeding value of Vernal alfalfa rising 76% per acre, primarily from yield increases due to potassium fertilization and three cuttings instead of two. The experiment showed that feeding value (% DMD as measured by the *in vitro* test multiplied by hay yield per acre) increased more than yields on an acre basis.

More frequent cutting—three times instead of two—actually improved feeding value or plant tissue quality. The younger forage had more feeding value than older material.

Three cuttings boosted UNFERTILIZED alfalfa yield only 11%, feed value only 32% above two cuttings. But P-K FERTILIZATION boosted 3-cut yields 40% and feed value a whopping 76% above UNFERTILIZED two-cuts.

On a practical farm basis, one acre of well-fertilized, frequently-cut Vernal alfalfa might produce 75% more feeding value than an unfertilized stand cut twice a year.

Although potash influences the feeding value of alfalfa indirectly, it has a very direct influence PER ACRE. Neither K nor P increased feeding value per pound of forage. But potash fertilization and frequent cutting boosted alfalfa's yields per acre, giving the grower much more of the younger, more digestible alfalfa.

BETTER STANDS—Potash helps build stronger, longer-lived stands, vigorous enough to survive winter, weeds, and non-desirable species.

Yields of second-year alfalfa rose on a Seward fine sandy loam topdressed with P and K, while the amount of weeds remained constant or under control in Michigan.

Dandelions invaded four-year alfalfa when NOT topdressed. These Michigan trials were relatively pure under both cutting treatments when fertilized annually with 166 lbs. K per acre.

ADDS PUNCH TO THAT EXTRA CUTTING

Increasing soil K from 90 to 240 lbs. per acre increased alfalfa yields and reduced other species on a Withee loam in North Central Wisconsin. Figure 2 shows the trend.

BETTER ALFALFA-GRASS BALANCE—To maintain high alfalfa level in an alfalfa-grass mixture, a grower must pour on the potash. This is a "must" if alfalfa is to be the primary source of nitrogen for the mixture.

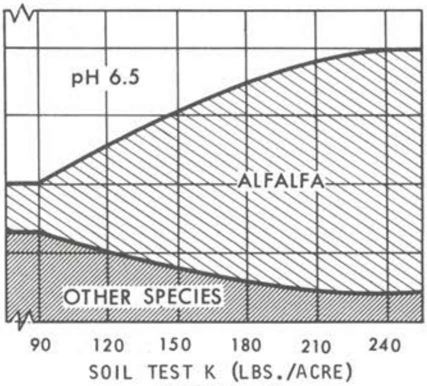


FIGURE 2

Virginia tests on a Cecil fine sandy loam showed seventh year alfalfa climbing from practically no yield to about 5000 lbs. per acre under yearly potash rates of 0 to 400 lbs. per acre. Orchardgrass dominated the mixture up to about 80 lbs. potash, then gave way to major alfalfa gains.

Potassium did not affect the balance of a 3-cut bromegrass-alfalfa system in its first harvest year on a Conover loam in Michigan. But in the second year, the bromegrass climbed only .66 to .78 ton with 80 to 320 lbs. potash yearly, while alfalfa jumped from 4.12 to 4.82 tons per acre.

BETTER INSECT CONTROL—Leafhoppers reduced Wisconsin hay yields of two alfalfa varieties 42% with low fertility, but only 25% when the soil was fertilized to a high level of 80 lbs. P and 200 lbs. K per acre.

Michigan alfalfa has shown a similar trend when topdressed with 166 lbs. K yearly.

THE END

Potassium Builds GRAPE QUALITY

★ **Helps insure large clusters of plump, evenly ripened berries.**

★ **Helps increase their sugar and acid content.**

★ **Helps prevent cluster-tip berries from drying out.**

JAMES A. COOK
UNIVERSITY OF CALIFORNIA

POTASSIUM is a "Jack of all trades" in plant life.

The 1966 Annual Review of Plant Physiology supports this idea in a study of mineral elements by Evans and Sorger. They point to the large number of enzyme systems in which potassium is known or thought to play a big role.

Grapevines do not experience "hidden hunger" for potash. Or if they do, the range of tissue K level associated with the hidden hunger is too narrow to diagnose. This means California vineyards will give more yield and better quality from potash applications only when potassium hunger symptoms show on the vines.

LOW-K AREAS—In California, low soil potassium has been found in very sandy soils and in vineyard areas that have been scraped in land-leveling operations.

To correct severe K-hungry vines, we have learned California soils demand very large doses of potassium sulfate—1500 to 3000 lbs.—deeply placed in the bottom of plow furrows.

When soils low in available potassium receive such treatment, things really begin to happen. Several vineyard trials have shown remarkable vine recovery. Fruit yields climbed, while the quality of the harvested fruit improved for market.

ON GRENACHE QUALITY—The two clusters of Grenache grapes on the facing page tell a story of potassium at work on grape quality.

The comparison is as unbiased as possible. It contrasts a cluster from non-treated, potash-hungry vines with a very typical cluster from a vine heavily fertilized with potash.

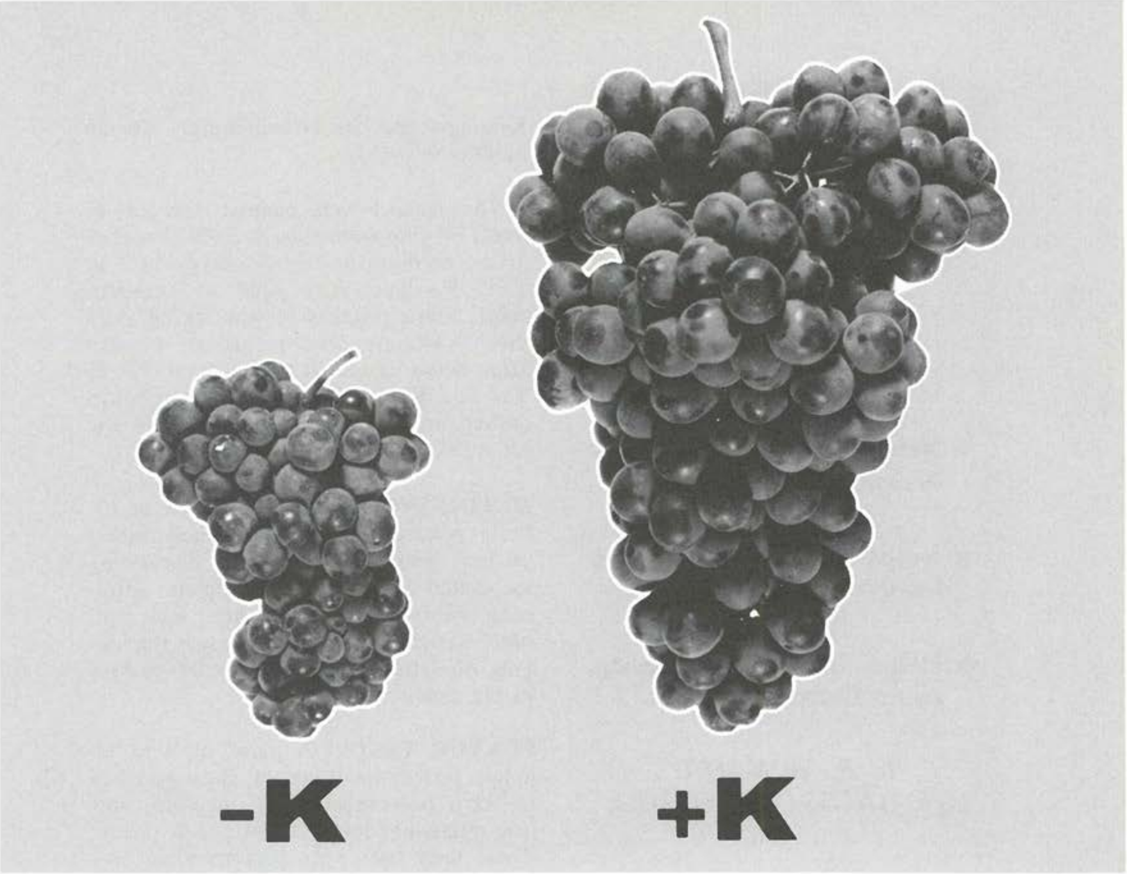
Before treatment, the well yielding vine and others like it had been scored as equally K-hungry as the non-fertilized vine. Potash treatment more than doubled the yields in this trial and sometimes tripled them.

The potash also greatly improved fruit quality with higher sugar and higher acid content. The table on the facing page shows this influence.

ON THOMPSON SEEDLESS—Fresno County Farm Advisor Peter Christensen reported in a 1965 BETTER CROPS that potassium increased Thompson Seedless yield 46%, berry size 31% over the no-K vines in the first year of a potash trial. And the grapes maintained the same sugar content.

But the most important thing potash did for Thompson Seedless fruit quality was to "remind" the vine of its cluster-tip berries.

On potash-hungry vines of this variety, berries at the cluster tip usually fail to show proper increase in sugar. As remaining berries approach maturity, the ones at



ADDS LARGER CLUSTERS EVENLY RIPENED

the tip dry into light weight husks not even usable for low quality raisins.

Potash treatments, both in Christensen's trial and in others by the author, have strikingly corrected this disorder.

QUALITY POINTERS—Potash-hungry fruit expresses itself according to the variety or species.

With Thompson Seedless, watch for cluster-tip berries drying out. With Grenache, watch for small tight clusters of small, unevenly ripening berries. With Eastern Concords, watch for poor set, very small berries, and frequent pre-harvest fruit shattering.

THE END

Fruit quality measurements on representative samples picked at the same time from potassium-deficient (check) and heavily fertilized plots

Treatment per vine	Fresh Fruit				Wine
	ppm K	% Sugar	% Acid	Grade *	% Alcohol
Check	796	23.3	.40	No. 6	13.2
8 lb K_2SO_4	926	25.7	.52	No. 2	15.2

* Based on sugar to acid ratio. No. 1 is best, No. 6 is lowest that is marketable.

Potassium Builds PEACH QUALITY

★ **Helps boost fruit size, weight, and yield.**

★ **Helps canned fruit hold bright color.**

★ **Helps insure favorably sour, sharp, tart taste.**

R. P. HUMBERT
LOS GATOS, CALIFORNIA

MANY FACTORS determine quality of canning peaches: size, color, flavor, texture, and nutritive value.

Peaches with low potassium appear to deteriorate more rapidly in the cans. To study this problem, cooperative research on Cortez, Andora, Starn, and Elberta peaches was conducted by the University of California's Departments of Food Science and Pomology, the food processing industry, and the American Potash Institute.

FRUIT SIZE & WEIGHT—Table 1 shows how potash fertilization increases average size, weight, and yield of K-hungry peaches. Fruit sizing increases up to mid-season leaf K levels of 1.3%.

YELLOW COLOR—When the trees were fed adequate potassium, Cortez and Starn peaches retained bright yellow color. But K-hungry peaches darkened after 3 to 24 months in the can.

The peaches were canned with leaf K levels ranging from 0.26 to 2.5%. Peaches in the medium and high ranges—1.3 to 2.5% K—held very good to excellent color. Starn peaches on the facing page show K-hungry peaches just six months after being stored in the dark at 72° F. The low-K peaches were beginning to darken and show red discoloring in the pit area.

DETINNING PROBLEM—Cans of Elberta peaches with lowest concentration of leaf potassium showed a blackening associated with almost complete detinning. Storage conditions were less than ideal. Later tests have not shown this degree of detinning with up to 24 months in the cans.

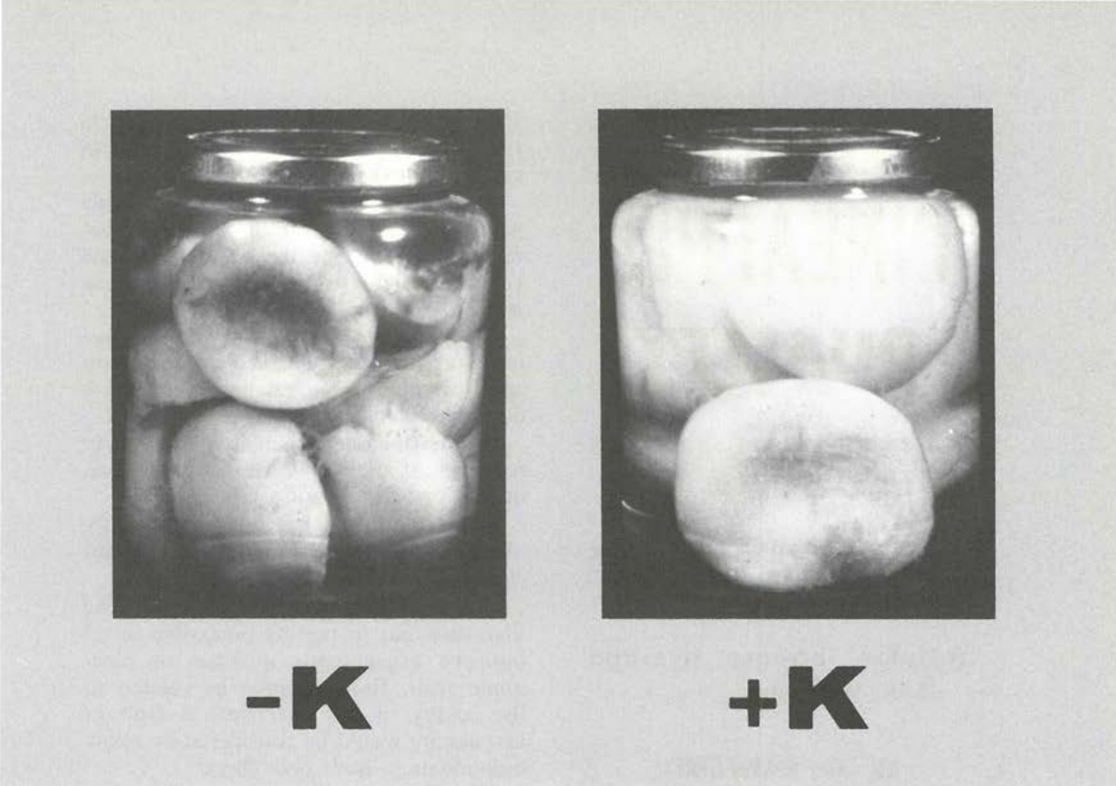
FLAVOR TESTS—A panel of 9 to 11 judges tested the flavor of Starn peaches to learn how much high, medium, and low potassium levels affect peach flavor. These taste tests were performed in November, 1966, after 6 months in the cans and in March, 1967, after 10 months.

They found marked differences at the three potash levels. The differences were consistent at both the 1966 and 1967 taste panels.

The medium-K peaches have a sharper, more sour, more tart flavor than the low-K peaches. The high-K peaches have the sharpest, most sour and tart flavor of the three K levels. The panel had a hard time distinguishing between the medium and high-K samples at the last testing period.

QUALITY POINTERS—These studies indicate canning quality of peaches may be improved by maintaining K levels in peach trees at medium to high potassium —1.3 to 2.4% K.

When potassium is low, watch for reduced fruit size, bright yellow fruit fading when stored in cans, red discoloring in pit areas, and increased detinning of the cans.



HOLDING QUALITY IN THE CAN

The flavor of Andora and Starn peaches grows more favorably sour, sharp, and tart with increasing potassium levels, a taste panel judged. **THE END**

TABLE 1. LOCATION, K-FERTILIZER TREATMENT, K LEAF CONTENT, FRUIT SIZE AND MARKETABLE YIELD—STARN PEACH VARIETY (4th leaf); Del Viento Orchard, California, 1960

Row [a]	12	13	14	15	16	17	18
K_2SO_4 [b]	10	0	25	0	10	0	25
Leaf K % [c]	.79	.30	1.29	.28	.90	.30	1.57
Fruit Diam. [d]	62.9	57.3	64.0	56.9	62.4	58.9	66.1
Mkt. Yield [e]	58	32	91	18	55	23	54

[a] Treatments applied to adjacent rows; 15 trees per row.
[b] Lbs. per tree applied 1/13/60 to alternate rows as indicated.
[c] Percent K in leaf at harvest 8/23/60.
[d] Avg. cross diameter of 600 fruits at harvest.
[e] Lbs. per tree marketable: >60 mm cross diameter.
After Lilleland, et. al. Proc. Amer. Soc. Hort. Sci., Vol. 81, 1962.

ATTEND WHOLE-STORY CONFERENCE

The whole story of potassium in agriculture will be covered at the conference on Potassium in Agriculture, June 18-19 at the National Fertilizer Development Center, TVA, Muscle Shoals, Ala. It is sponsored by the American Society of Agronomy, the Crop Science Society of America, the Soil Science Society of America, TVA, and the American Potash Institute. Experts will cover the many roles of potassium—from fertilizers to soil behavior.

Potassium Builds PINEAPPLE QUALITY

★ Helps increase the fruit's acidity.

★ Helps put golden yellow color on fruit flesh.

★ Helps increase average fruit weight.

W. G. SANFORD
UNIVERSITY OF HAWAII

A GOOD QUALITY pineapple has translucent flesh as contrasted to opaque, bright yellow appearance. It is free of blemishes or disease. It has adequate levels of sugars, acids, and esters to produce a pleasing flavor.

Much work has been done to learn how potassium nutrition affects the quality and characteristics of pineapple fruit. This report summarizes facts published by workers in South Africa, Ivory Coast, French Guinea (now Republic of Guinea), Australia, Taiwan, and Hawaii.

The findings summarized below are those that have been consistently observed or, based on results obtained on other crops, would be expected to occur with pineapple fruit.

Fruit Weight: When potassium is deficient, increasing levels of potassium fertilizer will increase average fruit weight or tons per acre.

Shell Color: Reports indicate potassium intensifies external yellow color of the fruit. Although shell color is important to fruit sold fresh, it is not a major factor in canned pineapple fruit.

Flesh Color: Deficient fruit has pale yellow flesh. Increasing increments of potassium will change the color from pale yellow to light yellow to golden yellow which is desired.

Fruit Translucence: Fruit translucence is reported to be increased by potassium application. This would be considered a desirable change.

Fruit Brix: Large increases in the Brix readings of pineapple fruit result when increasing rates of potassium are used.

Fruit Acidity: It has been consistently observed that potassium application increases fruit acidity.

Flavor: There have been reports in the literature that increasing potassium levels improve organoleptic qualities of pineapple fruit. But this may be related to the acidity of the fruit since a fruit of low acidity would be considered by many individuals to have poor flavor.

Miscellaneous: There have been isolated reports indicating that increasing potassium rates decrease fruit lodging, increase ascorbic acid, increase resistance to bruising, and prolong the shelf life of pineapples. These need further confirmation.

Table 1 compares typical results from potassium sulfate and potassium chloride. Adequate levels of ammonium sulfate were added to all treatments, insuring sulfur was not a limiting factor. Applying either potassium sulfate or potassium chloride increased average fruit weight, though increase from the former was much greater.

Fruit translucence was increased only when potassium sulfate was used.

Both carriers were equally effective in increasing Brix readings and titratable acidity of the fruit.

Although both carriers increased the number of fruitlets per fruit, the potas-

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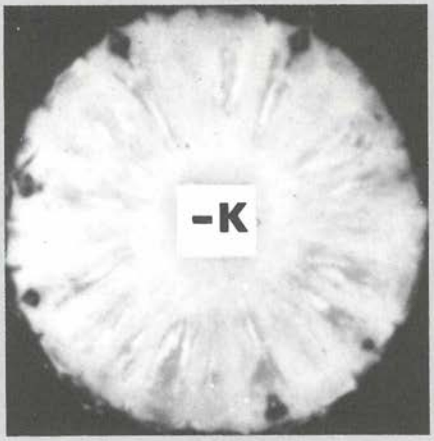
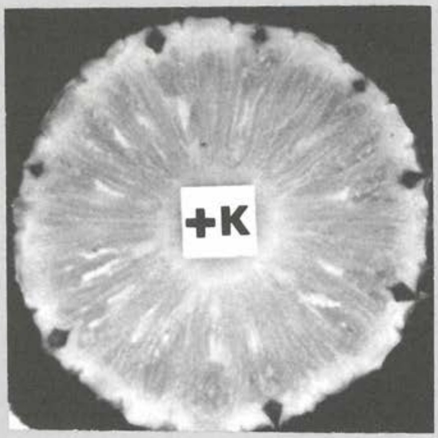
[1] Published with approval of the Director, Pineapple Research Institute of Hawaii, as a Technical Paper.

[2] Formerly Director & Plant Physiologist, Pineapple Research Institute, presently Professor of Agronomy, University of Hawaii, Honolulu, Hawaii.



OPAQUE



TRANSLUCENT

HELPS INSURE BLEMISH-FREE FLESH

sium chloride application decreased average weight per fruitlet to less than that of the untreated checks. Potassium chloride also delayed the maturity of the fruit.

Pineapple fruit small from mineral deficiency usually have poor quality too—that is, they are pale, opaque, and frequently blemished. As levels of the nutrient are raised from deficiency to sufficiency, fruit weight and quality improve.

At supraoptimum levels of a nutrient, there is either no further change or unfavorable changes in fruit weight and quality. It has been observed that supraoptimum amounts of potassium fertilizer can result in one or more of the following unfavorable characteristics: smaller fruit, tapered fruit, overly large cores, and delay in fruit maturity. But the general observation has been no great change.

Thus, all favorable characteristics associated with increasing increments of potassium occur between deficiency and sufficiency of potassium and parallel increases in fruit weight.

The one factor that appears to be unique with potassium is the increase in fruit acidity. This probably indicates potassium plays an important part in the organic acid metabolism of the pineapple fruit.

As a source of potassium, potassium sulfate is superior to potassium chloride. Pineapple appears to be very sensitive to chloride ions. The reasons for this are not known.

THE END

Table 1. Comparative effect of potassium sulfate and potassium chloride on fruit characteristics (data after Magistad, 1934)

Treatment	Avg. Frt. Wt. (lb)	Avg. Translucence (score) [1]	Brix (°)	Acidity (% citric)	Fruitlets (no./frt.)	Avg. Frtlet Wt. (gm)
No K	3.86	2.60	13.49	0.88	132.0	13.27
K_2SO_4-400 lb K_2O/A	4.30	2.95	14.62	1.14	144.0	13.56
KCL-400 lb K_2O/A	4.07	2.60	14.60	1.12	143.2	12.90

Potassium Builds
COTTON
QUALITY

★ **Helps improve fiber length, strength, fineness.**

★ **Helps increase boll and seed size.**

★ **Helps raise oil content.**

S. E. YOUNTS
DECATUR, GEORGIA

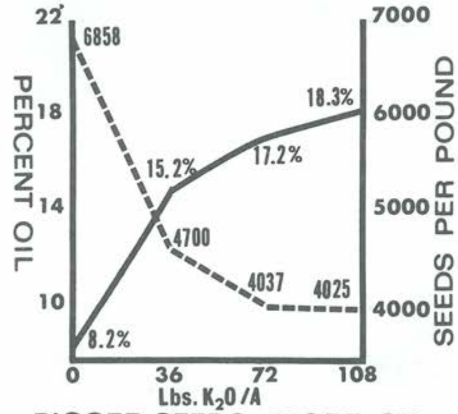
THE NEW FACE of cotton is quality. And ideas about quality are changing. Staple and grade were once the big traits.

Today and tomorrow fiber properties will be emphasized:

1—Length represented by upper half mean.
2—Strength measured by breaker instruments.
3—Fineness measured in micronaire or "mike" units. Color and cleanliness of lint will also be important.

What affects fiber quality? Weather, variety, seasonal changes all play a role. B. A. Waddle of the University of Arkansas cites 10 cultural practices affecting cotton growth and one or more of the fiber properties of length, strength, and fineness.

Among them are seed treatment, skip row, sub-soiling, chemical weed control, defoliation, excessive nitrogen, boron addition, and potassium for deficient soils.



BIGGER SEEDS, MORE OIL

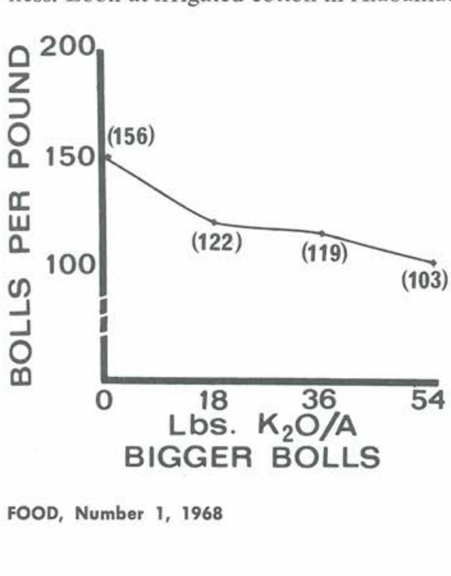
Right fertilizer ratio apparently improves fiber quality. Raising the proportion of potash improved the length and "mike" reading (fineness) of this Mississippi cotton but lowered fiber strength:

N-P_2O_5-K_2O Ratio Affects Cotton Fiber Quality

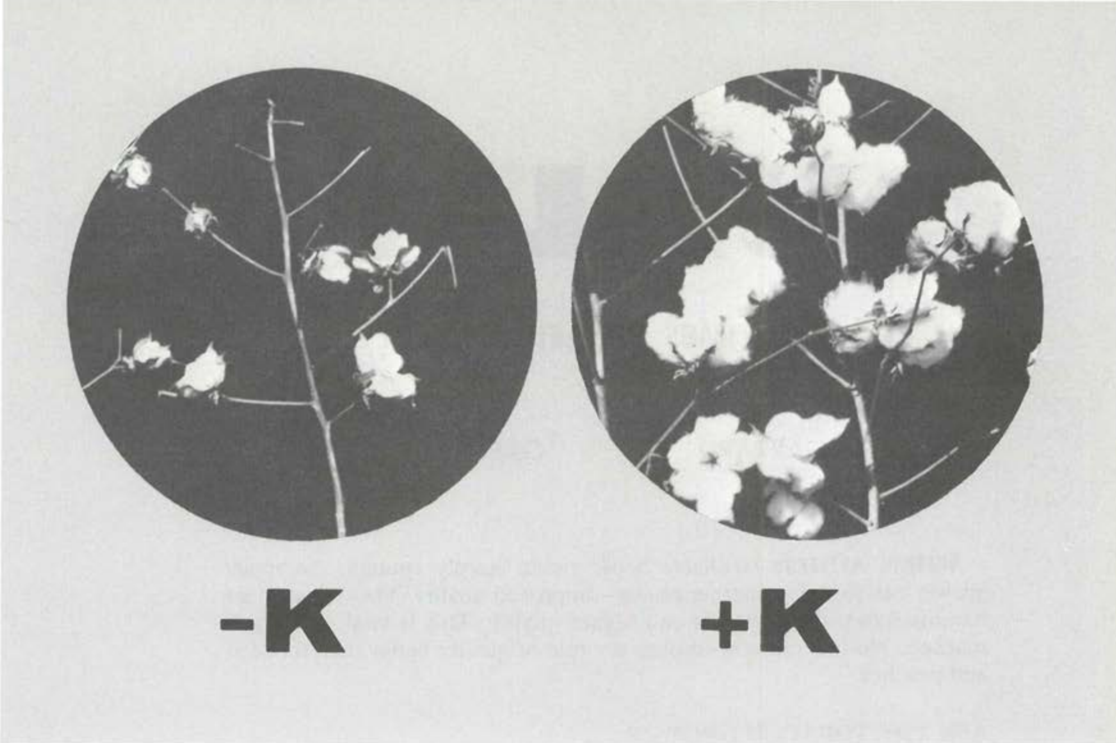
N-P205-K20	Length	Strength	Micronaire
(Ratio)	(UHM-in.)	(p.s.i.)	(mike)
1-1-0	.92	90,000	2.2
1-1-1	1.03	86,000	5.1
1-1-1.5	1.04	85,000	5.2

Mississippi Coastal Plain Experiment Station.

Adding potassium to deficient soils has influenced fiber length, strength, and fineness. Look at irrigated cotton in Alabama:



BIGGER BOLLS



ADDS STRONGER-FIBERED BOLLS

Potash Affects Cotton Fiber Properties (2-Year Average)

K20 (lb/A)	Length (UHM-in.)	Strength (g/grex)	Micronaire (mike)*
0	1.07	1.49	3.70
75	1.11	1.56	4.80
150	1.11	1.57	4.28
300	1.10	1.47	4.23
600	1.08	1.43	4.32

Auburn University and USDA.
*** Values below 3.5 are considered fine and above 4.9 as coarse.**

Note how the first increment of potash improved fiber properties. Good quality cotton depended on additional potash. The 300- and 600-pound treatments decreased fiber length and strength.

Potassium also affects boll size, seed size, and oil content of seed. More potash means bigger cotton bolls. Quality is the by-word of the cotton industry. Premium prices go to cotton with long, strong fibers of a desired micronaire value—neither too coarse nor too fine.

Top cotton yields require high soil fertility. If nutrient stresses occur, the cotton plant either fails to form squares or it sheds those squares already formed to compensate for the stress.

Fortunately for the grower, practices that increase quality generally increase yields. The grower shooting for top yields through right fertility and management can get top quality as a bonus. North Carolina research shows it below.

Fertilizer ($N-P_2O_5-K_2O$)	Seed Cotton Yield Lbs./Acre	Ave. Boll Wt. (gms.)	Mean Length	Mature Fiber %	% Lint	% Oil in Seed
60-50-0	1,037	4.74	27.2	67	39.6	14.66
60-50-30	1,439	5.42	28.8	75	39.0	17.53
60-50-60	1,739	5.85	28.9	79	39.1	18.74
60-50-90	1,738	5.74	28.6	80	39.0	19.44

QUALITY

SOMETIMES SPELLED KUALITY

HERBERT L. GARRAD GARRARD AG PHOTOS

WHEN ADDED fertilizers boost yields sharply enough, the smart grower can look for another bonus—improved quality. They seem to go hand-in-hand: higher yields and higher quality. This is vital on today's markets. No two crops symbolize the role of quality better than tobacco and peaches.

ASK THE TOBACCO GROWER . . .

He can tell you what quality means to his crop. These leaves show what potassium did to tobacco leaf quality. They were taken from two plots, midway up each plant. Each potash-starved leaf was placed over a potash-fed leaf.

The difference was striking. Nutrition affected leaf size and yields, leaf color, and texture. All tobacco growers know what these factors mean to the price they get per pound—and per acre, in the end.

ASK THE PEACH GROWER . . .

He can tell you what quality means to his crop. The size and color of the fruit greatly affect his income, not to mention the number of peaches per tree.

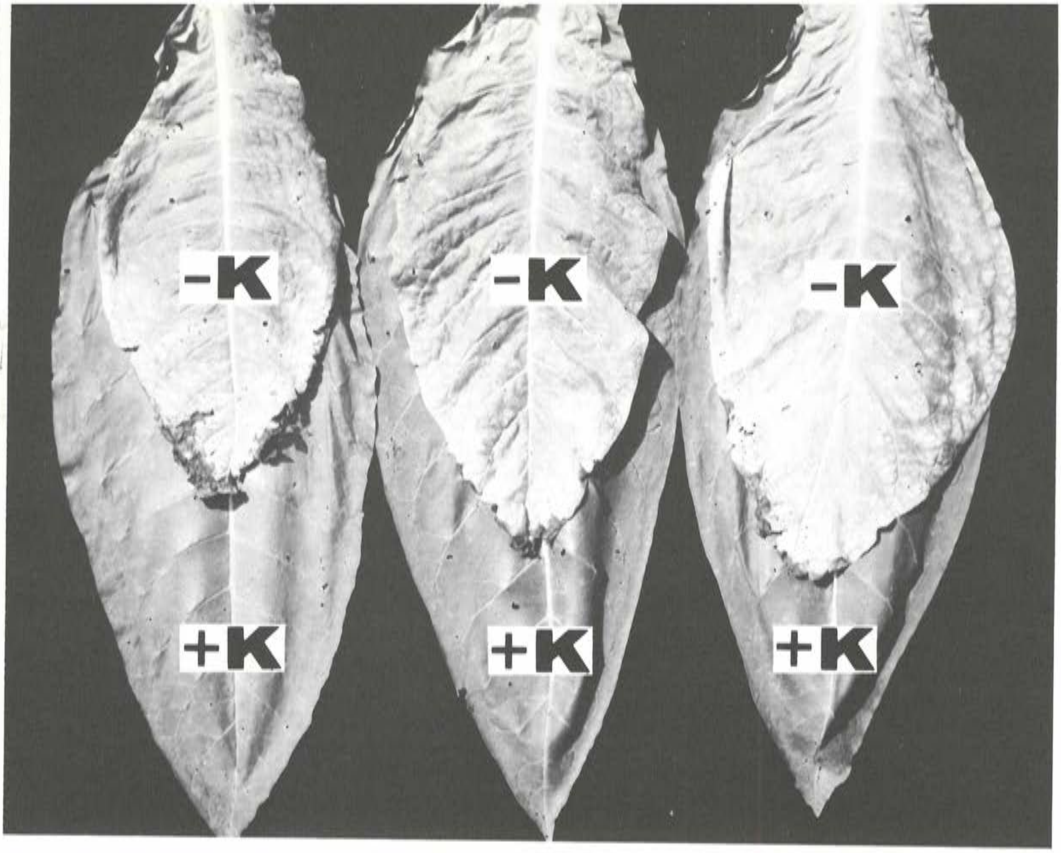
Nutrient levels and balance influence peach grades, new growth, fruit set, fruit size, and storage qualities. Research has shown potash-starved peaches have a higher respiration (breathing) rate, tending to break down faster after picking.

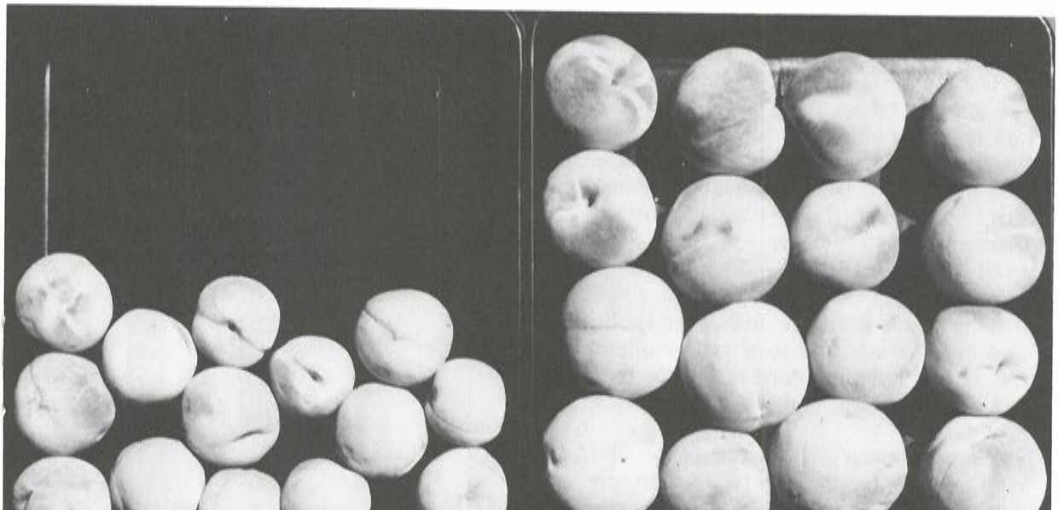
This is not to imply potash starvation alone causes poor storage qualities in peaches. But low available potassium with a high nitrogen supply seems to cause poor storage qualities. Research is seeking fuller answers to this phenomena. The need for adequate nitrogen-potassium ratio seems clear.

Sometimes both profitable increases and improved qualities may go unseen in a crop. Take 5 to 10-bushel increases in corn yields, for example. They cannot be judged by the human eye. Small BUT PROFITABLE improvements may be difficult to measure by the most exact yield-check methods.

Unseen quality differences may be detected by chemical tests, by storage trials, specific gravity tests, or feeding trials with livestock, etc.

THE END





-K +K

Potassium Builds LEMON QUALITY

★ Helps reduce peel thickness for smoother texture.

★ Helps raise percentage of juice in the fruit.

★ Helps increase concentration of total acid in the juice.

T. W. EMBLETON
W. W. JONES
UNIVERSITY OF CALIFORNIA

POTASSIUM (K) nutrition of lemon trees affects the quality of both fresh and products fruit.

The more fruit he can market fresh the greater return the California grower can realize. Fresh fruit outlets desire lemons harvested when they reach marketable size but before full yellow color comes. Fruit is degreened in "curing" (storage) before going to market.

FOR FRESH FRUIT—When trees are low enough in potassium to limit yields, they produce not only fewer fruits, but also many fruits that turn yellow on the tree before reaching market size for fresh fruit. Such small fruits are diverted to products.

When K-hungry trees get adequate potassium, the number of fruits increases. Adequate potassium delays loss of green color in the peel so the fruit remains on the tree longer to grow larger before harvest.

Table 1 shows how potassium fertilization affected three orchards—two deficient in K, one not deficient in it.

Potassium applications did three big things: (1) reduced peel thickness, (2) raised percentage of juice in the fruit, (3) increased concentration of total and ascorbic acid in the juice. Thin peel usually means smooth-textured peel.

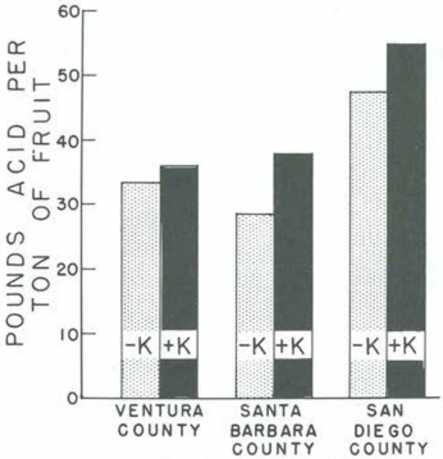
How much does added potassium improve fruit quality? That depends on the concentration of K in the leaves before treatment and how much added K increases this concentration.

In **Table 1,** the Santa Barbara County trees were not as deficient in potassium as the San Diego County trees. Yet, the Santa Barbara experiment showed greater improvement in fruit quality, because potassium applications resulted in a greater increase in leaf K.

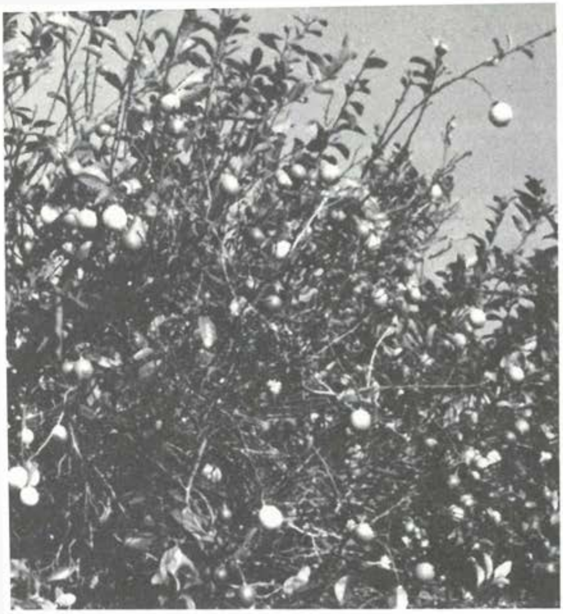
Additional K in the Ventura County trials increased leaf K greatly but improved fruit quality somewhat less than the other two experiments. Why? Because the trees initially contained relatively high K levels.

FOR PRODUCTS FRUIT—Returns from products fruit depend greatly on the pounds of total acid per ton of processed fruit.

Table 1 shows how the amount of acid in processed fruit depends primarily on three factors: peel thickness, juice percentage, and concentration of total acid in the juice.



K INCREASES FRUIT'S TOTAL ACID



-K
DEFOLIATED TWIGS

+K
DENSER FOLIAGE

The chart shows how these factors affected the pounds of acid per ton of fruit. Note how potassium applications resulted in a greater tonnage of fruit with more acid per ton. This K nutrition greatly influenced returns from fruit diverted to products in the Santa Barbara and San Diego County experiments.

In Ventura County, where K level was initially high, the effects were significant but not as great as those in the other counties, and no yield increase was recorded.

In the Santa Barbara and San Diego County trials, potassium applications improved not only fruit quality, but also tree condition shown by the pictures above.

Added potassium clearly benefits lemon fruit quality of orchards low enough in K to restrict yields. The effects in orchards moderately high in K are not so clear, but preliminary evidence suggests added K may be an important part of the fertilizer program even here.

Research is now seeking to learn how added potassium affects orchards where K does not limit yields.

THE END

Table 1. Potassium affects Lemon fruit quality and K in leaves.

Treatment	K in dry leaves, %	Peel thickness, mm	Juice by wt., %	Total acid in juice, %	Ascorbic acid, mg/100 ml juice
			Ventura County		
−K	1.37	6.04	29.6	5.60	60.0
+K	1.87	5.77	30.9	5.82	62.2
Significance	***	**	*	***	*
			Santa Barbara County		
−K	0.62	6.72	29.5	4.79	48.4
+K	1.23	5.94	34.3	5.46	53.0
Significance	***	***	***	***	***
			San Diego County		
−K	0.44	4.13	41.6	5.71	56.9
+K	0.66	3.88	44.2	6.33	60.3
Significance	***	*	*	***	**

Potassium Builds QUALITY in QUALITY GRASSES

★ Helps weatherize turf for winter cold, summer heat.

★ Helps toughen turf against disease and heavy traffic.

★ Helps boost turf energy, protein, & enzyme activity.

R. W. SCHERY
THE LAWN INSTITUTE
MARYSVILLE, OHIO

QUALITY TURF species—such as Kentucky bluegrass, fine fescues, bentgrasses, and bermudas—need fertilizer rich in nitrogen. Nearly everyone agrees, though some debate whether the nitrogen should be at least partly organic, including "slow-release" ureaform.

A mowed turf is meant to produce only green leaf, obviously stimulated and better colored by ample nitrogen. Nitrogen gives fast, striking results—so striking that other fertilizer components can be overlooked and their relation to nitrogen sometimes ignored. But nitrogen cannot do the job alone.

It is true that very few cases of minor element deficiency have shown up in naturally growing turfgrass. These are almost entirely confined to iron on alkaline soils or to temperamental grasses such as centipede in the Southeast. As far as I know, there has been only one or two other cases of minor element deficiency in lawns, such as copper on peculiar Florida soils.

This is not to imply we have mastered the role major elements play.

Take phosphorus, for example. It is very important to the seedbed and to good rooting. But why does it frequently immobilize in the soil, although not necessarily unavailable to the plant root? Why does it interact with other elements, "counteracting" arsenic influences, for example? The answers are not yet clear to us.

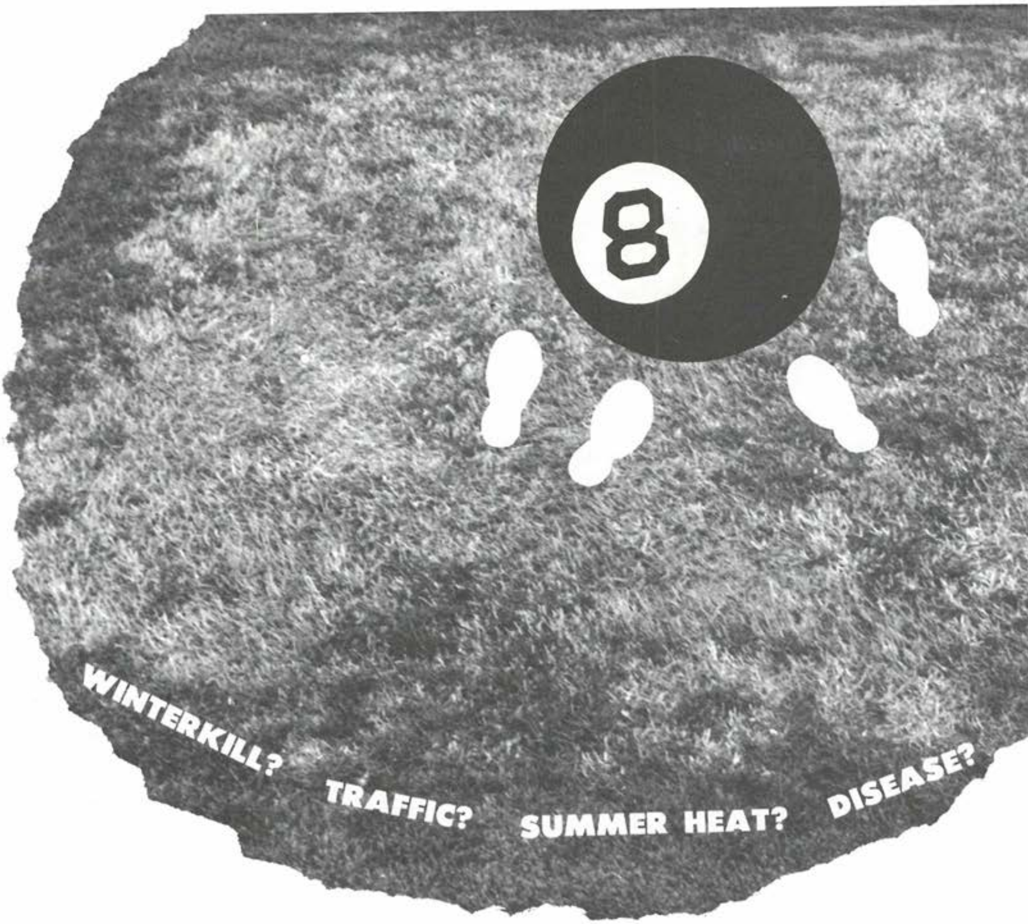
Potassium has long been a vital element in food production, but until recently somewhat slighted in our turfgrass research. Research is now uncovering important needs for adequate potassium and phosphorus in lawn and turf fertilizers.

The evidence is clear country-wide, from Florida to Washington. The potassium symposium and other reports featured at the 1967 American Society of Agronomy sessions make this clear:

NORTH CAROLINA (Gilbert and Davis)—Have shown that K improves the cold tolerance of Tifdwarf and Tifgreen bermudagrasses. High nitrogen and low potassium give the least resistance to cold. Greatest winter hardiness comes when potassium about equals nitrogen. But half to two-thirds as much potassium as nitrogen seems ample for winter-tender varieties to be used many miles further northwestward.

Gilbert's literature survey shows that potassium, when adequately balanced with nitrogen, helps northern grasses (bluegrass and bent) better tolerate both low and high temperature.

WASHINGTON (Goss and Gould)—Have reported that high nitrogen and low potassium cause non-protein nitrogen and unused carbohydrates to accumulate. Such a physiological condition, they theorized, favors disease invasion. And they



HELPS KEEP TURF FROM GETTING BEHIND

found ample potassium suppressing *Ophiobolus* disease in the field.

FLORIDA-IOWA (Markland and Roberts)—Have called for the right nutrient "balance," noting that potassium influences root growth and foliage stiffening. Horn of Florida believes adequate potassium improves growth, quality, and behavior on most southern grasses.

ALABAMA (Sturkie and Rouse)—Have confirmed that adequate potassium improves color, growth, and winter hardiness on zoysia and bermuda. When potassium was inadequate, they found browning, dwarfing, slow spring recovery, and possible damage from cold.

VIRGINIA (Foy and Jones)—Have found there is generally no antagonism between potassium and herbicides.

MARYLAND (Wagner)—Has summarized the influence of potassium on turf metabolism. How potassium boosts turf energy, protein and enzyme activity. How it improves root growth, as well as cold and disease resistance. How it slows down plant respiration (breathing rate), reducing water loss and wilting. How too little potassium encourages winterkill and disease, reduces density and quality.

These reports, and similar findings from Michigan State, focus new attention on the importance of potassium to turfgrass. Many experts now seem to think that potassium should equal at least half the amount of nitrogen to insure complete, balanced turf fertilization. This applies to soils not naturally rich in potassium, of course.

THE END

Potassium Builds RICE QUALITY

★ **Helps create smooth, glossy light-colored grain.**

★ **Helps influence the number of filled grain.**

★ **Helps insure grain with good protein quality.**

H. R. VON UEXKUELL
TOKYO, JAPAN

LIKE MANY crops, rice depends on adequate potassium to improve its quality. Why has this fact received such little attention?

1—Because rice quality is a complex thing, somewhat vague and obscure.

2—Preferences for scent, shape, color, palatability, etc. vary by food habits of different countries.

3—Plant food affects a grain crop's quality less obviously than it does more bulky crops with higher moisture content. Small differences in texture, shape, taste, color, etc. show up more easily in bulky crops.

4—Rice is rarely graded and priced by appearance of the hulled grain, as in Japan, but sold as rough rice by weight only in the tropics where unhusked rice stores better.

5—Potassium hunger does not show up as commonly or as obviously on rice as it does on other crops.

We have long known how greatly potassium improves the quality of wheat, corn, and malting barley. Of course, variety affects quality more sharply than fertilizer does. The better a variety responds to a fertilizer the better that fertilizer can influence its quality.

ON OUTSIDE QUALITY—Potassium-hungry grains are small, with a rough surface. Under severe hunger, brown spots will show on the grain. But grains well fed with potassium are usually larger, with a glossy, smooth surface that is lighter colored than K-hungry rice.

Such grains have better milling rate. But too large a grain may be less hard than small and medium sized grain. Potassium does not increase grain size or the 1000 grain weight of all varieties.

Potassium-hungry plants are more susceptible to many rice diseases than well fed plants. Some of the diseases not only affect the total yields but also the quality of the grains.

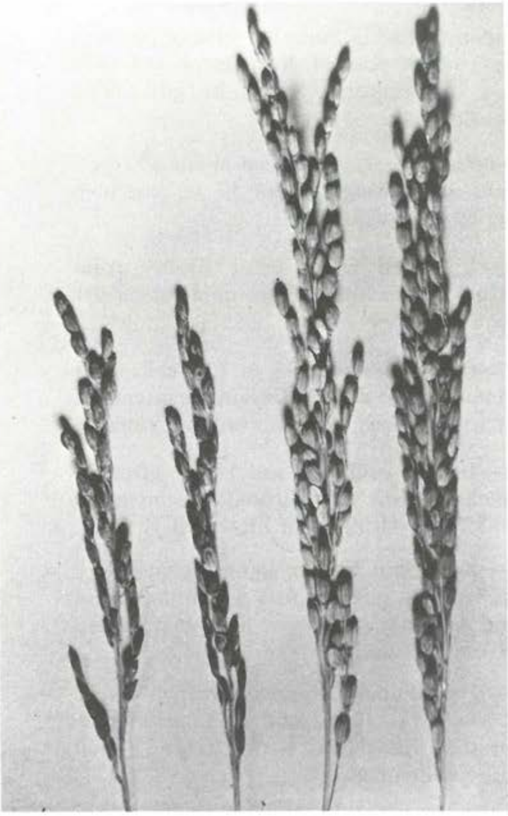
Potassium supply often affects the number of filled grain. We know the pollen of K-hungry plants contains inadequate starch for proper germination, causing many flowers of the K-hungry ear to go unfertilized.

But don't assume potassium application will always improve quality. It works, in most cases, where plants are deficient in it or where the plant's nutrition has been unbalanced.

ON INSIDE QUALITY—How does potassium affect the intrinsic quality of rice? We know little about this. But we do know grain from K-hungry plants usually contains more total sugars and less total carbohydrates than grain from healthy plants.

Potassium affects nitrogen metabolism of rice plants. This may be a very important influence. In Asia, where most of the people get most of their calories and protein from rice, the composition of the nitrogen fraction in the grain will be a very important factor.

In potassium-hungry plants, a larger proportion of the total nitrogen is present in the ammonia-nitrogen and amide-nit-



-K **+K**

-K **+K**

ADDS SMOOTH, GLOSSY, PLUMP GRAIN

rogen form. This means K-hungry grains produce a protein of inferior nutritional value and quality.

Protein differences in the grain will not be as large as differences in the leaves, of course. But in extreme cases, up to 70% of all protein intake during adult life of some Asian people may come from rice. The accumulation of small differences can grow into a major nutritional deficiency for such people.

Nitrogen fertilizer applied to rice will become a very important factor in supplying badly needed protein. To increase the grain's protein content, late nitrogen applications may become a popular practice.

Heavier nitrogen use, late applications, and fertilizer responsive varieties will increase nutritional imbalances in rice culture. Many soils of the tropics are inherently low in potassium. Increased nitrogen use will aggravate this condition.

But more nitrogen will be needed to produce more rice with a higher protein content. So, potassium will be needed not only to balance the nitrogen for increased yield, but also to improve the quality of the protein produced by the heavier nitrogen usage.

To end human hunger we must first end plant hunger among the crops that feed all humans around the world.

THE END

Potassium Builds POTATO QUALITY

★ Helps develop top-yield tubers.

★ Helps boost growth rate for mature potatoes.

★ Helps insure light-color chips for market.

G. E. WILCOX, JOHN HILGER
S. L. LAM
PURDUE UNIVERSITY

"**SCIENTISTS** consider potassium the meat and potatoes food that makes plants grow healthy . . ."

That's the way a New York Times article recently described this quality-building element. Indiana research agrees with it.

Research on field-grown potatoes and a greenhouse project showed how much potatoes need potassium to produce healthy plants and quality chips.

POTATO CHIPS—Table 1 shows what happened to irrigated potato plants grown in sandy loam soil on the Paul Klein farm in Southwestern Indiana.

Potassium-hungry plants produced less tuber yield and darker chips than the K-fed plants. The better K-fed the plants the better tuber yield and chip quality they produced.

Table 2 shows what happened to potato yields and chip quality in a greenhouse experiment conducted by John Hilger in Purdue's Horticulture Department. Growing Superior variety potatoes in 10-inch pots of K-deficient soil (120 lbs. exchangeable K/A), he got telling results:

1—Green weight climbed about 192 percent, tuber weight about 37 percent with added potassium.

2—Increased yields came mostly from larger tubers rather than more tubers per plant.

3—Quick tissue tests 8 to 12 weeks after planting showed potassium content of plant sap rising with increased K rates.

4—Leaves collected and tested after 10 weeks growth also showed K content of leaf tissue rising with increased K rates.

5—Potassium hunger signs became clear at 8 weeks growth: first as stunted vines and darker green leaves, later as bronzing of older leaves.

6—Potato vines responded to each higher K level while tuber yield appeared to level off after the 400 lbs. K rate in the 10-inch pot confinement.

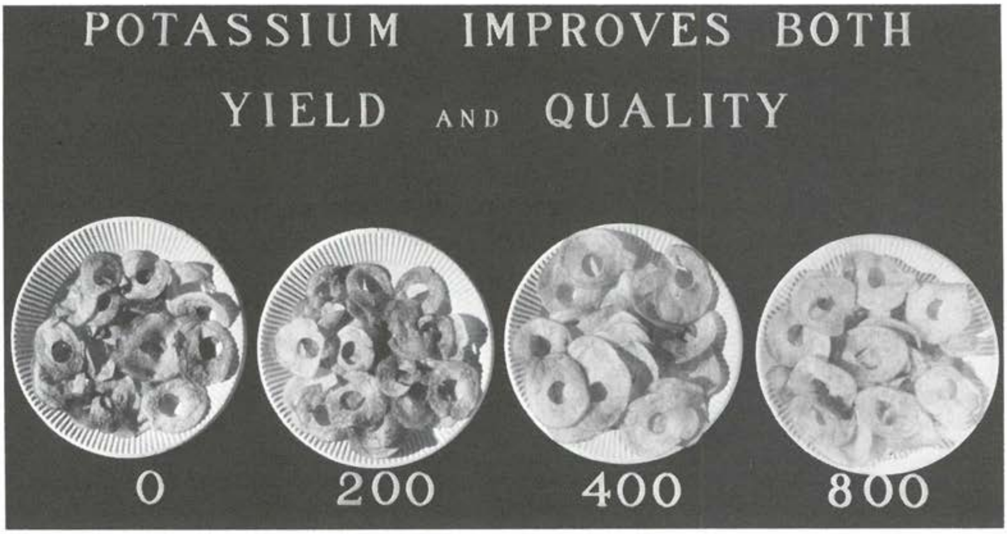
7—Chip quality depended on color. Dark colored, low quality chips came from potatoes receiving low potassium rates. Uniform, light colored chips came from tubers receiving 400, 800, and 1200 lbs. of potassium per acre.

WHY? Variety and tuber maturity influence chip color. Mature tubers make best chipping. And potassium influences both plant growth and tuber maturity to-

Table 1. Potato leaf composition, tuber yields, and chip color from various fertilizer treatments on the Paul Klein farm in Southwestern Indiana.

Rate of K applied[a] lbs/A	K content of upper mature leaf (blade and petiole) at heavy tuber set %	Tuber Yield CWT/A	Chip Color
0	1.6	248	Dark
65	2.5	276	Light
130	2.1	312	Light
195	2.6	324	Light

[a] 160 lbs exchangeable K/A in soil.



ADDS MARKET-PLEASING POTATO CHIPS

ward specific harvest dates. It influences the plant's metabolism which in turn can reduce the sugar and amino acid content that tend to darken chips.

Potatoes grown in Southwest Indiana are harvested in July. If low-K level holds back growth rate and tuber development, the K-hungry potatoes are more immature and produce darker chips.

LETTUCE—Market value depends on leaf succulence and tenderness and freedom from blemishes. Under certain conditions, greenhouse grown Bibb lettuce can develop tipburn on margins of young and enlarging leaves just as the plants approach maturity.

Plants grown under long days and intense light developed very much tipburn, Dr. S. L. Lam found in Purdue Horticulture Department tests. He eliminated the tipburn by adding 8 g KCl to the vermiculite media in a 13″ x 10″ pan.

Just remember: one crop of leaf lettuce (30,000 lbs. per acre) will remove 150 lbs. K per acre. Such high removal, plus costs of lower yields and blemished-leaf trimming, demand close control of K fertilization.

THE END

Table 2. Greenhouse Pot Experiment. By John Hilger under Dr. Hafen. Department of Horticulture, Purdue University. Feb. 11 to May 5, 1967.

Treatment K applied[a]	K Content of Expressed Sap		Total K in Mature Leaf	Green Foliage Weight[b]	Tuber Yield[b]	Chip Color
lbs/A	8 weeks ppm	12 weeks ppm	10 weeks %	lbs/plant	lbs/plant	
0	1000+	1000	.99	1.3	3.5	Dark
200	2000−	1000	3.40	2.3	3.5	Dark
400	3000−	1000	3.50	2.6	4.5	Light
800	3000	2000	5.53	2.9	4.5	Light
1200	3000	3000	6.45	3.8	4.8	Light

[a] 1/3 of K applied as KCl mixed with soil before planting, 1/3 of K applied as liquids–plants 6 inches tall, 1/3 of K applied as liquids—30 days after 2nd application.
[b] Average of four replications.

Potassium Builds BANANA QUALITY

★ Helps increase dry matter content and rind thickness.

★ Helps intensify flesh color and improve flavor.

★ Helps shorten maturity time and lengthen storage life.

C. T. HO
TAIWAN POTASH RESEARCH FOUNDATION

RAPID AND luxuriant growth of the banana demands much potassium. The best proof is the heavy potassium used by high yields.

A recent survey of many experiments showed very high fruit yields—above 30 metric tons per hectare—paralleling added potassium up to an amazingly high range of treatments.

They showed that a high banana yield requires an extra heavy dressing of potash even up to 1,000 kg K_2O per hectare or higher.

FOR FRUIT CHARACTERS—An experiment conducted by Provincial Junior College of Agriculture in Pingtung, Taiwan, showed average weight, length and circumference of fruit finger, and rind thickness all increasing with added potash.

The potash increased both rind weight and flesh in a way that maintained the flesh to rind ratio at about 2:1 without affecting either appreciably. **Table 1** shows how potassium fertilization affects the characters of banana fruit.

Fruit hands weighing under 1.5 kg are sorted for low-price sales on the local market. So, profit losses from inadequate potash fertilization are greater than yield drop implies.

A trial by Fenshan Tropical Horticultural Experiment Station found potassium increased dry matter content of fruit, intensified flesh color, and improved flavor.

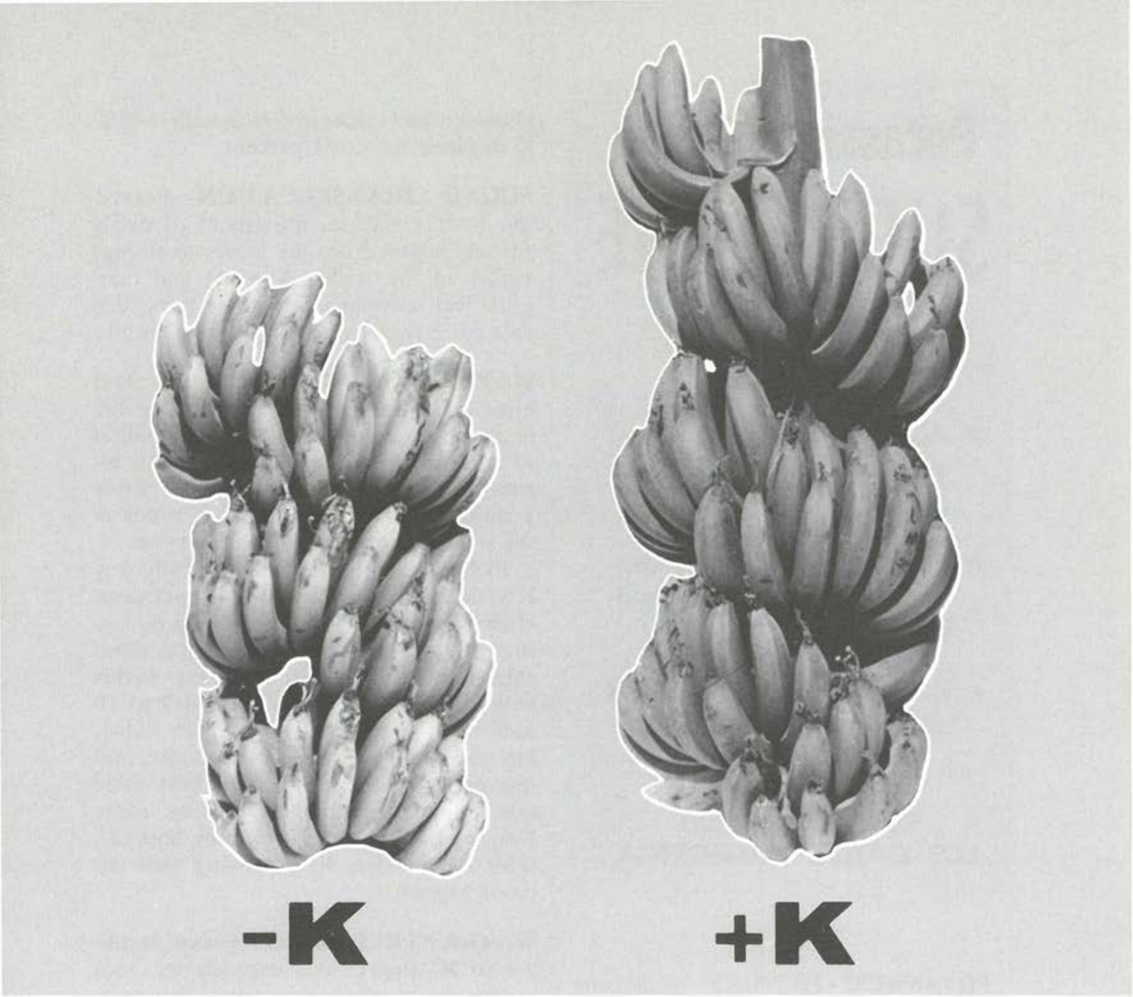
FOR FRUIT MATURITY—In many experiments, potash fertilization stimulated early shooting and shortened time required for fruit maturity. This is very important for winter and spring fruits. Both fruits depend on an early harvest for a good price.

In ten banana potash trials, the 3rd and 4th hands of banana bunches at the same degree of maturity were stored under room temperature in May. **Table 2** shows the conditions of the banana fruits after 20 days.

Bananas receiving potash kept longer

TABLE 1. CHARACTERS OF BANANA FRUIT AS AFFECTED BY POTASH APPLICATION

K_2O g/plant	Weight of bunch (kg)	Weight of hand (kg)	Weight of finger (g)	Length of finger (cm)	Circumference of finger (cm)	Thickness of rind (cm)	Flesh/Rind weight ratio
0	9.5	1.44	101.1	15.8	10.5	0.23	2.15
220	11.9	1.65	111.0	17.3	11.0	0.26	1.93
440	12.6	1.75	111.9	17.0	11.2	0.27	2.19
660	12.9	1.79	120.2	17.8	11.3	0.29	1.89
880	13.0	1.78	124.1	17.6	11.9	0.28	2.00



than those without K. In fact, these trials showed bananas from K-hungry plots suffering nearly 4 times more rotten fingers than fruit from the triple-K plot.

Bananas require 160-200 g of nitrogen and 50-100 g of phosphate per plant per year. But the most profitable potash rate for this crop ranges from 450 g to 600 g, or even higher, under Taiwan conditions.

Demonstrations, field days, and farm seminars have gradually convinced technicians and farm advisors that potassium is a major profit booster. In 1962, the Food Bureau recommended only 54 kg per hectare for bananas, but suddenly raised it to 360 kg per hectare in 1966.

And some farmers are applying much more—correctly in most cases.

THE END

TABLE 2. THE CONDITIONS OF BANANA HANDS AFTER 20-DAY STORAGE

K_2O g/plant	% Rotten fingers	Status of banana finger
0	48	Flesh and peel dark brown; whole flesh inedible.
160	35	Flesh brown colored; 1/3 of flesh edible, the rest rotten.
320	33	Flesh brown colored; a part of flesh edible, the rest rotten.
480	10	Flesh keeps yellow color; all flesh edible, flavor good.

Potassium Builds SUGARCANE QUALITY

★ Helps insure larger leaf area for storing sun energy.

★ Helps increase sugar content, improve juice quality.

★ Helps build drought and disease resistance.

ROGER HUMBERT
LOS GATOS, CALIFORNIA

POTASSIUM - HUNGRY sugarcane produces lower yields and poorer quality, requiring more tons cane to produce a ton of sugar.

LEAF AREA—Leaves on the facing page show what potassium hunger can do to a cane plant. The K-fed stalk had 14 green leaves, all active in sugar-making. The K-hungry plant had only 7 green leaves, with three more lower leaves severely "scorched." The well-fed leaves provide 4 times the green leaf area for (photosynthesis) storing the sun's energy.

SUGAR SYNTHESIS—Potassium hunger reduces photosynthesis rates, radiocarbon studies showed in Hawaii. Normal appearing leaves with 0.91% K had 10% less photosynthesis rates than normal leaves of 1.70 to 1.89% K. The photosynthesis rates of leaves with 0.40% K declined 84 to 93 percent.

SUGAR TRANSLOCATION—Potassium hunger reduces movement of newly formed sugars from the leaves to storage tissues in the stalks. Necrosis and marginal leaf scorching can cut translocation rate more than half that of normal plants.

MATURITY PERIOD—The cane plant must have enough potassium during the maturity period to avoid an accumulation of non-protein nitrogen and reducing sugars, and a lower sucrose recovery. **Table 1** shows the importance of N-K ratios in the 8-10 sections of stalks at harvest.

Fields with high N and critically low K yielded less than 7 tons sugar per acre. High moisture, high reducing sugars, low sucrose, and low purities required more cane to produce a ton of sugar. Fields with medium N-K levels yielded 7 to 10 tons, with lower moisture, lower reducing sugars, higher sucrose and purity, and improved juice quality. The best juice quality and yields, 10 to 13 tons, came from high K-low N. Thirty-nine Mexican trials have shown K improving cane sucrose percent.

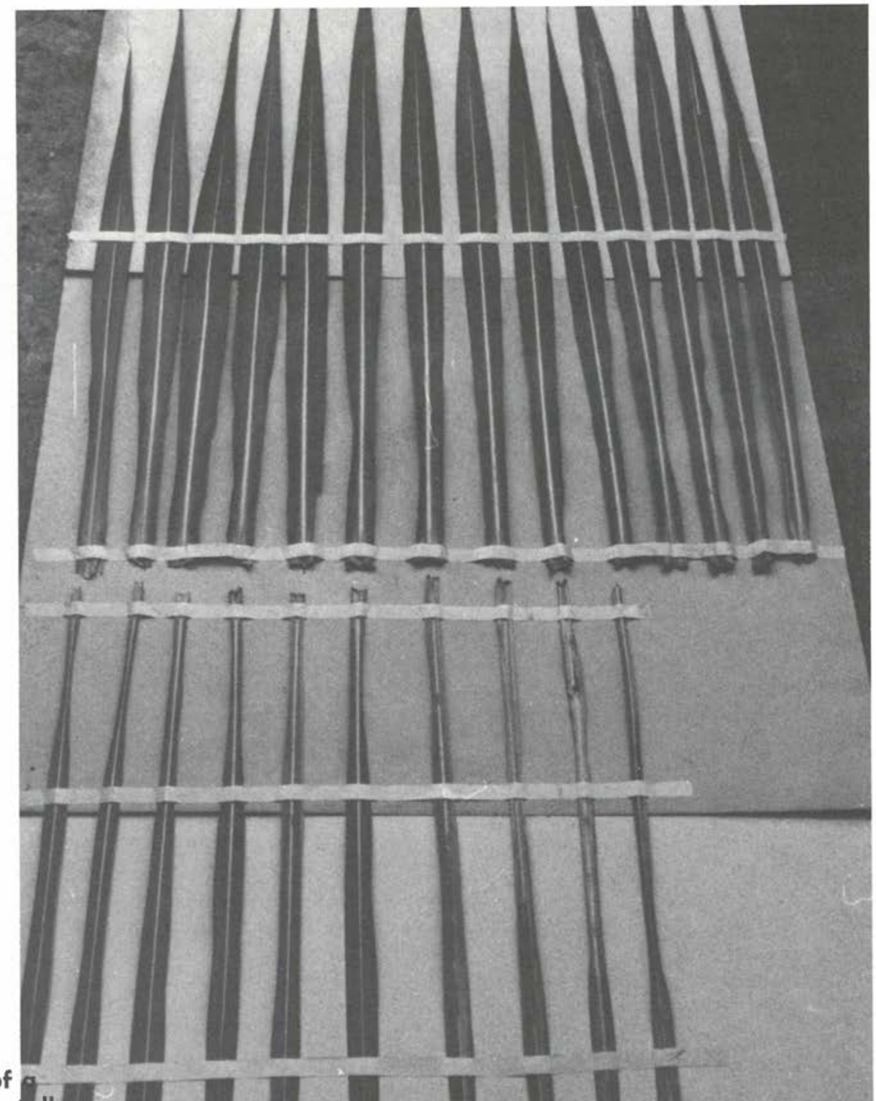
WATER STRETCHING—Potash fertilizer in K-hungry soils expands the root system to reach more water. Adequate potassium in leaves helps maintain turgor, reduces plant breathing rate (respiration), and gives water balance needed for best synthesis of sugars and sucrose storage.

DISEASE RESISTANCE — K-starved plant tissues deteriorate rapidly. Thin cell walls rupture. This invites open house to "Red Rot" and other secondary infections. K strengthens cell walls. Locsin in the Philippines reports K fertilization increased resistance to breakage and rat damage, while lowering stalk mortality.

THE END

+K

-K



Leaves of a NCo310 stalk 13 months old. From Xicotencatl, Mexico.

TABLE 1. PREHARVEST ANALYSIS OF 8-10 STALK SECTIONS FOR 37-1933 FIELDS AT LIHUE, HAWAII, 1955

Field yields	H_2O %	N %	K %	Total Sugars %	Reducing Sugars %	Sucrose %	Tons Cane/ Acre	Tons Cane/ Ton Sugar	Tons Sugar/ Acre	Purity
<7.00TSA	80.70	0.42	0.68	49.2	11.8	37.5	72.2	10.62	6.80	81.7
7.0-9.9	77.10	0.25	1.22	48.4	6.4	41.7	86.9	9.64	8.94	85.2
10.0-12.9	75.30	0.19	1.47	51.9	5.7	46.2	79.8	7.13	11.20	88.2

K
POTASSIUM

PROTEIN BUILDER—Lack of potassium leads to disturbances in N metabolism, favors the hydrolization of proteins and, eventually, the accumulation of toxic N-containing substances. The most important of these substances, which are generally lacking in high-K plants, is putrescine. Since K is also needed as activator of the enzymes pyruvate kinase and blutamine synthetase, potassium is essential for the basic processes in which organic acids are made available as NH_2-acceptors for the formation of amino acids or amides.

The general effect of potassium fertilizers is to increase the effectiveness of nitrogen fertilization as plants are able to synthesize higher molecular substances like sucrose, starch, protein and lipids.

TEAMWORK FOR FORAGES—M. R. Teel (USA) reported the influence of nitrogen-potassium relationships on the quality of crude protein. When cultivating forage crops under different N-K treatments, Teel observed grasses grown with inadequate potassium accumulated amide nitrogen while transformation to protein was reduced. It may be of considerable practical importance that there was a poor relationship between total nitrogen and true protein at low potassium levels. It is assumed that there is a connection between non-protein nitrogen in the forage and nutritional disorders.

Teel found that high nitrogen, as well as low potassium, cause an increase in the concentration of organic acids, chiefly malate. To neutralize these acids, the plant needs cations such as K, Mg, Ca or NH_4. Failure to supply cations which enable nitrogen-fertilized grasses and legumes to assimilate ammonia, results in abnormal levels of non-protein nitrogen.

NEUTRALIZING ORGANIC ACIDS—K contributes to the maintenance of certain electro potentials at the cell membranes, which play an important part conditioning the permeability for cations and determining the speed and the direction of the flow of water and the metabolites. As shown by experiments of Wyskrebentzewa (USSR), the membrane

...and the QUALITY of Agricultural Products

SOME HIGHLIGHTS FROM 8TH CONGRESS OF INTERNATIONAL POTASH INSTITUTE BRUSSELS

From International Fertilizer Correspondent

potential of the root tissue decreases constantly as the deficiency of potassium becomes more severe. 20 days after the beginning of the deficiency the potential does not exceed one fifth of its initial value.

Due to the intimate relationship between potassium and acidity, the supply of K has a great influence on fruit quality. Over a wide range of crops, soils and climatic conditions it was found that potassium increases the titratable acidity of fruits. 1. Arnon (Israel) particularly mentioned citrus, apples, peaches, pineapples and tomatoes. Increased K fertilization also results in reduced losses of acidity during storage.

ENERGY BUILDER—Potassium promotes formation of carbohydrates, their translocation and their condensation to higher molecular substances. Potassium deficiency reduces rate of photosynthesis per unit leaf area. Furthermore, many results of biochemical research show that K deficiency leads to increased respiration rates. It could be demonstrated by Kursanow that a diminishing K supply to pumpkin roots caused ineffective respiration. In this case, the absorbed oxygen does not contribute to the synthesis of energy-rich compounds.

FOR OILS & FATS—Oils and fats are derived from carbohydrates. Maximum oil production by the plant will therefore be obtained under conditions favorable to the production of carbohydrates. It has been found that potash fertilizers exert a favorable effect on the oil content of fruits and seeds. According to Arnon, this was particularly confirmed in the case of tung fruits and soybeans.

FOR FULLER VITAMINS—Fertilizers can influence the vitamin content of food crops.

The carotene (provitamin A) content in vegetables is positively correlated to increasing applications of nitrogen. Since there are close connections between the contents of chlorophyll and of carotene. the deficiency of any plant nutrient which may affect the green color of the leaves, whether N, K, Mg or trace elements, will also reduce the carotene content.

Many experiments have shown that an

adequate supply of potassium increases the content of ascorbic acid (vitamin C) in a number of crops. Arnon mentions in this connection citrus, black currants, pineapples, tomatoes, potatoes, spinach, cabbage and mango (13 references). The beneficial effect of K on vitamin C contents of plants is easily explainable from the fact that ascorbic acid is a product of the carbohydrate metabolism which is strongly influenced by the supply of potassium.

FOR FRUIT MATURITY-STORAGE—In a number of fruits, the ripening process is characterized by a disintegration of pectic substances. For tomatoes, high rates of K increased the activity of pectic enzymes and favored high yields of quality fruit. K-deficient apples did not ripen normally, and were of low quality.

For fruits that have to be transported long distances or stored over weeks or months, keeping quality is a factor determining market value. The state of maturity in which the fruit was harvested is very important for the storage ability. But it can also be influenced by fertilizer application. The favorable influence of potassium fertilization on keeping quality was not only confirmed with apples, etc. but with stone fruits as well. It is ascribed to the reduced respiration intensity in K-rich fruits. Similar results were observed in the case of carrots and potatoes.

FOR FRUIT SIZE-COLOR—Potassium, almost without exception, was found to increase the size of citrus fruits (Arnon cites 10 references) and of peaches. Under the influence of P or K deficiency small apples were obtained.

The response of potatoes to fertilizer application was such that the treatment which produced the highest total yield gave the largest yield of grade 1 potatoes. Low potash supply resulted in a large proportion of very small tubers.

Fruit color is often positively influenced by potassium. The color of apples seems to be directly related to the K content of the leaves. The beneficial effect of potash on fruit coloration was confirmed in experiments with peaches and tomatoes.

ON SUGARBEETS—On sugar beets, potassium application increased sugar content, improved juice purity, and decreased the contents of noxious nitrogen and of sodium. In connection with the influence of K on sugar content, S. Trocme and G. Barbier reported that they had observed—in their long-term fertilizer experiments at Versailles—a higher sugar content in the beets on fields that had received ample potassium in the past, compared with fields where potassium was supplied only recently.

FOR VEGETABLES—Tomatoes have been the object of many studies elucidating the influence of fertilizers on yield and fruit quality. G. W. Winsor (United Kingdom), reporting on potassium and the quality of glasshouse crops, mentioned that potassium improves uniform ripening and diminishes ripening disorders (blotch). The proportion of hollow tomatoes is likewise reduced with higher K dressings. The particular influence of potassium on fruit color was stressed by M. Woods (Ireland).

M. Lavalleye and H. M. Steppe (Belgium), reporting on the effects of potash on pea production and quality, confirmed the effect of K on the length growth: potash-deficient plants are smaller in size and have shorter distances between the individual nodes. During the reproductive phase the number of pods is influenced by potassium and its interaction with nitrogen and magnesium. A sufficient supply of phosphorus is of decisive importance for the development of the pea plant.

A. Malguori (Italy) mentioned that the quality of artichokes is favorably influenced by high rates of nitrogen which retard the formation of lignin substances. The undesirable effects of N, delayed maturity and increased sensibility to pests, can be counteracted by balanced applications of P and K. The importance of phosphorus to stimulate early flower formation is well established. Recent experiments have revealed that also K dressings show particularly favorable effects in this regard. **THE END**

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