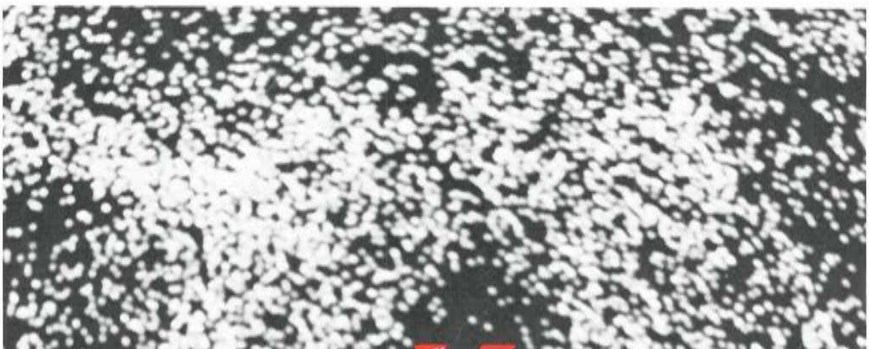
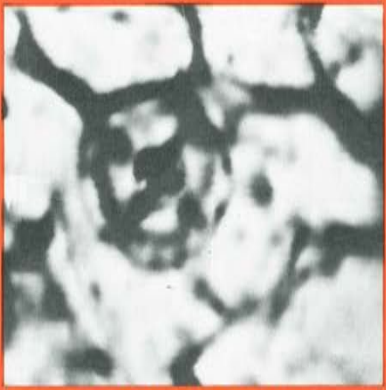
Better Crops WITH PLANT FOOD

FALL—1971 25 CENTS



PUMPING FOR A BETTER LIFE

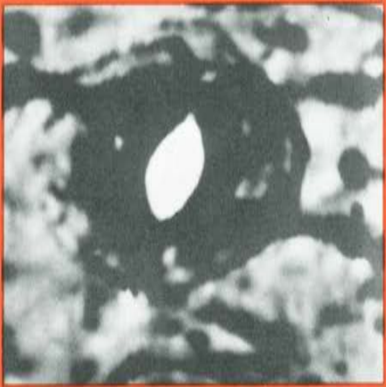
Leaf in dark 2 hours . . .



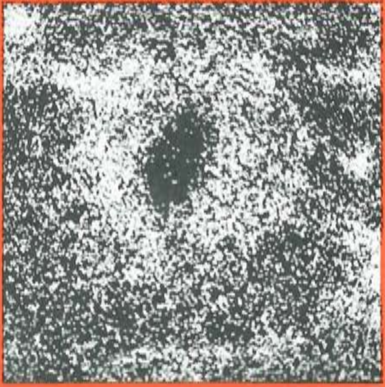
CLOSED LEAF STOMATE

LESS K (White Spots) IN GUARD CELLS

. . . then in light 1.5 hours

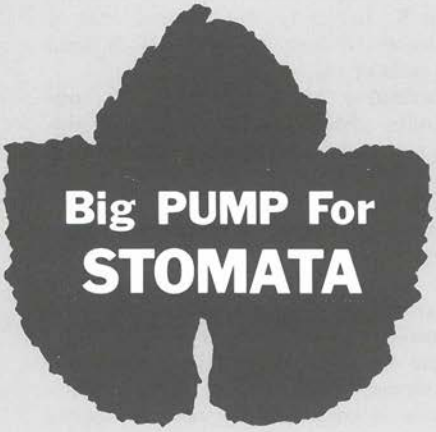


OPEN LEAF STOMATE



2.5 TIMES MORE K IN GUARD CELLS

Big PUMP For STOMATA



. . . THOSE TINY PORES on the surface of all leaves that will close the history of man and all his environmental problems if they ever stop opening.

SCIENCE HAS LEARNED . . .

No other element can substitute for potassium in providing necessary solute for water movement that leads to open stomata . . . permitting an acre of 100-bushel corn to exhale enough clean oxygen in one summer to keep 12 people breathing for a whole year.

B. L. SAWHNEY, I. ZELITCH
UNIVERSITY OF CONNECTICUT

POTASSIUM PLAYS a vital role in photosynthesis, the process by which plants take up carbon dioxide (CO_2) from the atmosphere and convert it to sugars, using energy from the sun.

Science has known for almost 50 years that plants low in K take up less CO_2 than normal plants. But more precise measurements of photosynthesis and its relation to K in plants have been made only recently.

In 1966, Peaslee and Moss at this Station observed that stomata (the tiny pores controlling CO_2 flow into the leaf) of K-deficient corn leaves were less open than the stomata of normal leaves. Uptake of CO_2 by K-deficient leaves was also less.

Similar observations were made on alfalfa by Cooper, Blaser and Brown in Virginia in 1967.

OUR EXPERIMENTS help to establish the precise role of K in opening and closing of leaf stomata and hence, in photosynthesis.

We know stomata in most plant species open in the light when guard cells surrounding the pore take up water and become more turgid than adjacent cells on the leaf surface. Stomata opening thus requires movement of water into the guard cells.

But water moves only in response to pressure gradients caused by differences in solute concentration between guard cells and adjacent cells.

Soluble carbohydrates produced by photosynthesis in guard cells have long been thought to be the solute responsible for water movement.

But recent investigations by Fujino in Japan and by Humble, Fischer, and Hsiao in California suggested that K accumulation in the guard cells provides necessary solute for water movement, and hence for stomatal opening.

WE HAVE TESTED this hypothesis by using the electron microprobe technique.

This permitted us to determine the amount of potassium concentrated in regions smaller than one-millionth of an inch within individual guard cells.

For qualitative estimates, we obtained pictures of the potassium distribution in larger areas containing a pair of guard cells and adjacent cells.

Our results show that stomatal opening is controlled by active transport of K into the guard cells.

We placed tobacco leaves from greenhouse-grown plants in the dark for several hours so that the stomata closed. From these plants, leaf discs were cut, placed on water, and illuminated to get open stomata.

Then the discs were placed in the dark for varying periods to get different stomatal openings. After these treatments, portions of the lower surface of leaves were quickly stripped off and freeze-dried under vacuum. The freeze-dried samples were then analyzed by the electron microprobe.

THE PHOTOGRAPHS show (1) the portion of the leaf analyzed and (2) the distribution of K in the corresponding area.

The number and brightness of the white spots are proportional to the concentration of K. It clearly shows guard cells of the closed stomate contain less K than guard cells of the open stomate.

Quantitative measurements of K concentrations showed K in guard cells increased linearly as the stomatal opening increased—**and the guard cells of a fully-opened stomate contained more than two-and-a-half times as much K as that of a closed stomate.**

The K concentration in guard cells of open stomata could provide enough solute to increase guard cell turgidity.

These findings provide direct evidence that stomatal opening and hence photosynthesis is controlled by active transport and accumulation of K in the guard cells.

THE END

NO substitute

SCIENTISTS have found a missing link to the question of HOW potassium influences opening of stomata on leaves, vitally affecting plant growth.

In SOIL AND WATER, University of California (Davis) scientists G. D. Humble, R. A. Fischer, and T. C. Hsiao identified a detailed physiological process in which potassium is absolutely required and cannot be replaced by other ions normally found in plants.

They explain, "We have long known stomata open by inflation of guard cells through absorption of water. The inflation results osmotically from the buildup of solutes in guard cells. What had not been resolved in more than a half century of research is what the solutes are and how they are built up to cause stomata opening.

"We have found strong evidence that solutes build up for opening through uptake of potassium by guard cells in osmotic amounts. Potassium is specifically required for opening brought about by light—no other physiological ion can substitute for potassium in this crucial role.

"We managed to obtain strips of epidermis from leaves of broadbeans (*Vicia faba*) with their guard cells still functioning as in intact leaves. Such strips eliminated complications caused by the rest of the leaf in stomata studies.

"Effects of ions and other chemicals were tested by floating the strips on solutions. Using solutions of various ions at dilute and physiological concentrations, only potassium (and rubidium) allowed full opening of stomata in light. Ions such as sodium, ammonium, magnesium, and calcium permitted little or no opening.

"We used radioactive isotope to determine total potassium taken up during opening process. From these data we found sufficient amount of potassium was absorbed to act osmotically to produce opening.

"Energy for potassium uptake came from light, probably via the process called cyclic photophosphorylation. Closing of stomata in the dark is apparently brought about by the reverse process—a loss of potassium from the guard cells, followed by loss of water and deflation."

Better Crops
WITH PLANT FOOD

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Irrigating Corn On CLAYPAN Soils...

C. M. WOODRUFF, UNIVERSITY OF MISSOURI
In The University's Science and Technology Guide

THE TECHNOLOGY of producing corn has progressed to a stage where 150 bushels per acre and more may be obtained if adequate, but not excessive, water is provided through supplemental irrigation.

With 24,000 to 26,000 plants per acre in 30-inch rows, with adequate fertility, with chemical weed and insect control and hybrids suited to high populations, over 200 bushels per acre have been obtained using sprinkler type irrigation.

When irrigating claypan soils, consider these things:

1. **The moisture content** of the surface soil should be kept sufficient to prevent water stress in plants, especially during pollination and grain formation.
2. **The amounts of water** applied should be so limited that developing plant roots will remove the available water from the deeper soil layers. This leads to a more vigorous, higher yielding plant, less need for added water, less runoff if rain falls after irrigation, and an oxidized state of the claypan reflected by better crop yields the succeeding year.
3. **Rates of application** of water should be low enough to permit the water to be drawn into the soil by capillarity to prevent structural breakdown and puddling of the surface soil that would occur if it became saturated with water.

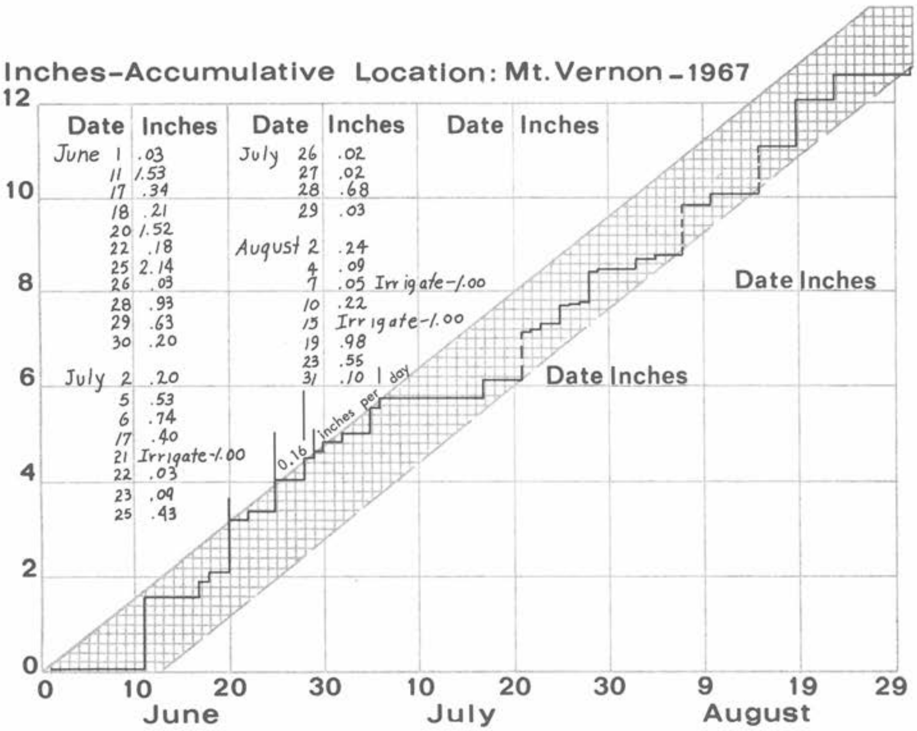
Points 1 and 2 may be achieved best with sprinkler type irrigation. A fair compromise may be achieved with furrow type irrigation by running water between every other row.

Soil moisture investigations under corn have shown the precipitation requirement of the crop for best performance is less than its total water requirement for the growing season by the amount of available water stored in the deeper soil layers.

In most growing seasons, the average precipitation requirement from June 1 to September 1 may be taken as 0.16 inches per day. To maintain suitable amounts of water in the surface plow depth of soil, the accumulative deficit of precipitation at any time should not exceed two inches.

In sub-humid regions, various amounts of precipitation occur at unpredictable intervals. So it becomes necessary to chart the accumulation of precipitation and water added as irrigation in order to keep the amounts within prescribed limits. An example of such a chart for the 1967 season at Mt. Vernon, Missouri is supplied.

GUIDED by a water chart



The accumulative water chart is a suggested guide for irrigating claypan soils.

This chart consists of a solid line with a slope of 0.16 inches per day from June 1 to the last of August. Parallel to this line and two inches below it is a dashed line. For shallow soils and extended hot dry periods a line at a deficit of 1.75 or even 1.50 inches may be more appropriate. And on deep soils in cool seasons deficits of 2.25 to 2.50 inches may be acceptable.

The deficit of 2.0 inches provides a fair guide for claypan soils within the limits of our present experience.

To use such a chart, we assume the soil profile is fully charged with water on the first of June when corn plants normally are too small to have removed much water from the soil.

Records of daily rainfall may be tabulated on the chart as shown in the sample chart. At the time the amount of precipitation is tabulated it also is drawn as a vertical line on the chart.

Days without precipitation are drawn as a horizontal line from the top of the line for the last day with precipitation. Thus the precipitation is accumulated graphically in a stair-step fashion across the chart.

If the amount of precipitation gives a vertical line that rises above the upper limit represented by the solid sloping line, that portion above the sloping line may represent excess water that would produce runoff.

This should be confirmed by observing whether or not the rain caused runoff through ditches and creeks in the vicinity. Then make a note of it on the chart. The sample chart suggests that runoff would have occurred on June 20, 25, 28, 29 and July 6.

In most instances, the soil profile is filled with water while corn plants are small, and sufficient rain to produce runoff will occur some time during June. This establishes the base from which to enter the drier portion of the summer when the needs for irrigation will arise.

Following the prolonged wet conditions from June 11 to July 6, there came eleven days without rain. A rain of 0.40 inch on July 17 alleviated immediate need for irrigation. But the maximum deficit of 2 inches to be tolerated was reached four days later on July 21, indicating supplemental irrigation would be desirable.

Applying one inch of water on July 21 would have moistened the surface plow depth, yet left space to accumulate as much as one inch of precipitation should rain have occurred immediately after irrigation.

With the added irrigation and some showers, another irrigation was not indicated until August 6 to 7, and then again on August 14 to 15.

The corn growing season of 1967 was very favorable in southwestern Missouri, with yields exceeding 100 bushels per acre without irrigation. But one irrigation of corn plots near Asbury, Missouri added 44 bushels more corn per acre.

A summary of Missouri precipitation records indicates **an average requirement of four irrigations of one inch each per season,** based on the method of charting irrigation needs just described.

It is anticipated that measurable benefits will be derived from supplemental irrigation of corn most of the time. **THE END**

ECONOMIC considerations

IN CLAYPAN SOIL areas, the source of water may be impounded water through dams. A general rule of thumb is that 10% of the land area would need to be in water impoundment.

Value of land assumed to be $300 per acre.

Cost of water area/A	**$30**
Cost of building dam/A	**60**
Cost of pumps and pipes for furrow irrigation/A	**60**
Investment/A	**$150**

Without irrigation the 20 yr. avg. corn yield in the Missouri claypan area would be about 75 bu/a. With irrigation 150 bu/A is possible. To get the extra 75 bu the farmer has two choices:

Buy another acre at $300/A
Invest in irrigation at $150/A

Variable costs without irrigation/A	**$55**
Additional variable costs with irrigation-seed, fertilizer, harvesting, hauling, and labor and power for applying water/A	**35**
Total variable costs with irrigation/A	**$90**

Drouth is a major limiting factor in Missouri's claypan soils. Over a 31-year period at Columbia, 4 to 8 one-inch irrigations each year would have been required in 16 years. Thus, without irrigation corn yields would have been reduced seriously one half the time.

Such drought hazard causes farmers without irrigation water to use lower plant populations and less fertilizer than those with irrigation water.

Those with water get bonus yields in good seasons when irrigation is not needed and in bad seasons get better prices along with better yields.

The farmer is interested in increased stability of yields and income. He must consider the risks, investment costs, and financial gains in making a decision on irrigation.

Is Your TILLAGE SYSTEM Changing Your Soil Fertility Pattern?

J. C. SIEMENS, W. M. WALKER, T. R. PECK
UNIVERSITY OF ILLINOIS In ILLINOIS RESEARCH, Summer 1971

IN MANY NEW tillage systems, such tools as the chisel plow, disk and field cultivator are being substituted for the moldboard plow.

Since these tools do not completely incorporate the residues from the previous crop, they leave the soil surface in a good condition for erosion control.

Another advantage is that they do not require as much time and power as does use of the moldboard plow.

These tillage systems may also cause some problems. The fertility pattern of the soil may change, for example, becoming unsatisfactory for high yields.

So, it may be necessary to sample and test the soil differently than if the moldboard plow is used.

An investigation of these potential problems was begun in 1966 on the Agricultural Engineering Research Farm at Urbana. That year all plots in the experiment received 2 tons of agricultural limestone, after which they were moldboard-plowed and planted to soybeans.

Corn has been grown on all plots since 1967. The five tillage methods listed in Table 1 have been used in three replications.

In 1967 and 1968, all plots received a band application of 17 lbs N/A; 29.5 lbs P (67 pounds of P_2O_5); and 15 lbs K (67 pounds of K_2O) at planting.

In 1969, the same amount of fertilizer was applied broadcast before planting. Anhydrous ammonia at 200 lbs/A was applied in June of every year.

Soil samples were obtained from every plot in 1969. Two sampling techniques were used: (1) A core was taken from the soil surface to a depth of 9 inches. (2) Samples were taken at each of three depths—0-3, 3-6, and 6-9 inches.

Table 1. — Tillage Treatments and Corn Yields, 1968 and 1969

Tillage treatment	Yield, bu./A.	
	1968	1969
Disk, moldboard-plow, cultivate, harrow, plant . . .	143	135
Disk, chisel, cultivate, plant . . .	146	123
Disk twice, harrow-till, plant . .	140	134
Rotary-till twice, plant	134	139
Chop stalks, till, plant	139	137

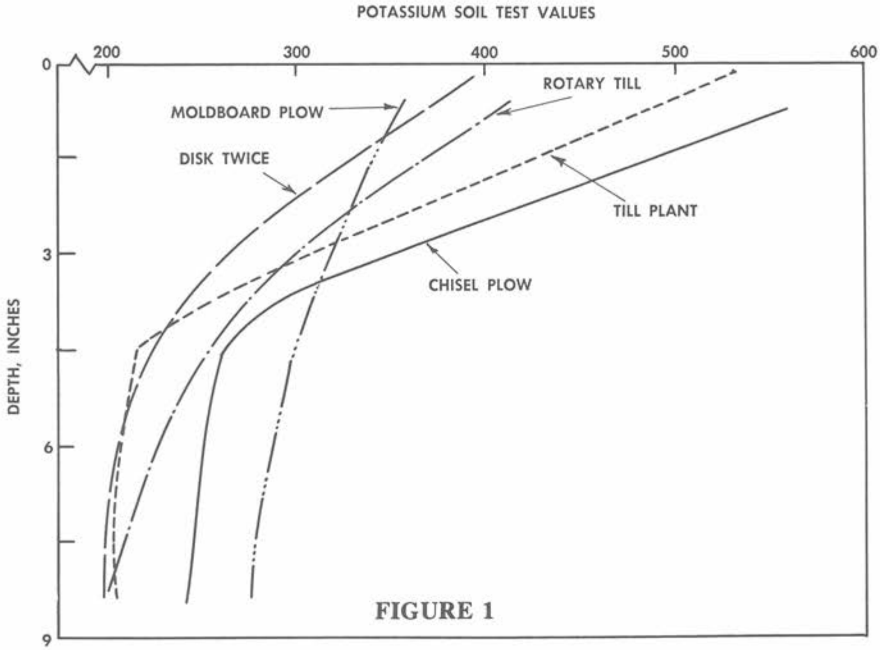


FIGURE 1

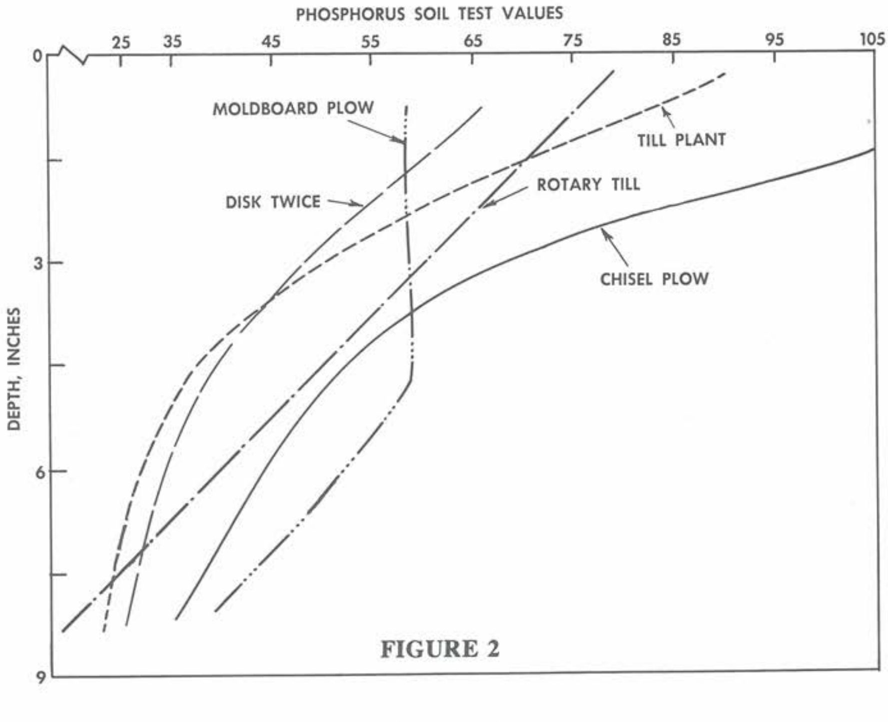


FIGURE 2

Table 2. — Average Soil Test Values, 0-9 Inch Depth, 1969

Tillage treatment	pH	P	K
		lb. per A.	
Disk, moldboard-plow, cultivate, harrow, plant . . .	5.8	52	298
Disk, chisel, cultivate, plant . .	5.7	62	314
Disk twice, harrow-till, plant	5.7	63	296
Rotary-till twice, plant	5.8	60	282
Chop stalks, till, plant	5.5	45	272

All samples were analyzed for soil acidity (pH), phosphorus, and potassium.

YIELDS FROM ALL treatments were fairly high (Table 1). Plots receiving the disk-chisel-cultivate-plant treatment yielded significantly less than moldboard-plowed plots in 1969.

This was the only significant yield difference between the moldboard-plowed plots and the other plots.

Total soil fertility was essentially the same on all plots, as indicated by the soil tests of samples taken to a depth of 9 inches (Table 2).

However, the moldboard-plowed plots were more uniform with depth than the others (Table 3, Figs. 1 and 2).

The highest fertility values at the 0-3 inch depth were on the chisel-plowed plots. The differences between these values and the values on the moldboard-plowed plots were large enough to be significant.

The rapid decline in test values with depth on all plots except the moldboard-plowed ones indicates that the nutrients did not move vertically through the soil.

Since the operating depth of the chisel plow was 9 inches, a better mixing of fertilizer throughout the top 9 inches might have been expected.

However, trends in soil test values for the other treatments were not greatly different from what we would normally anticipate.

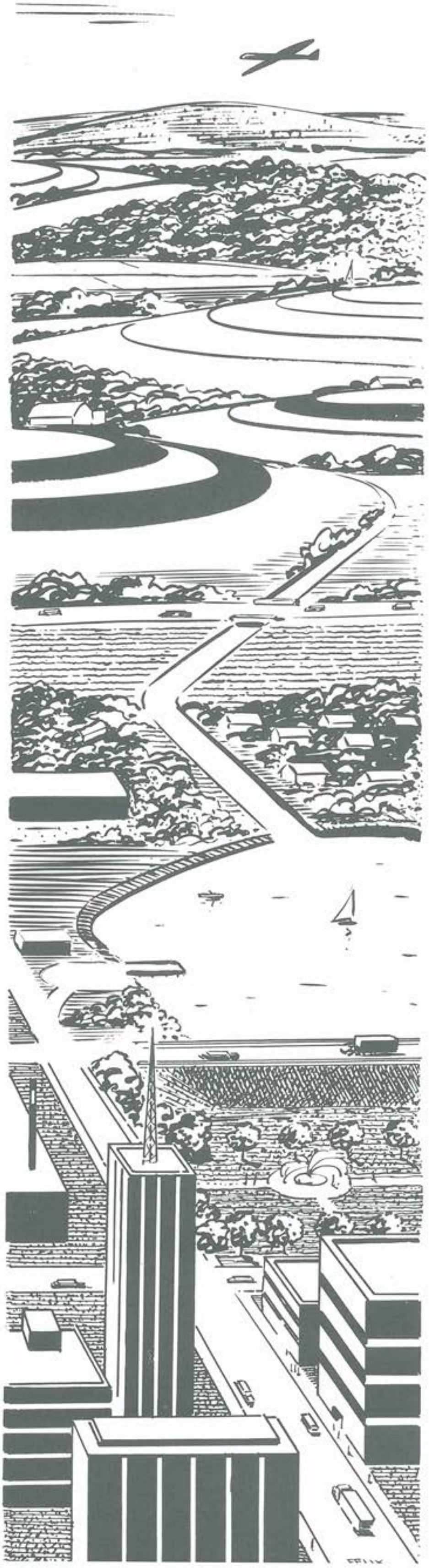
IF THE NEW TILLAGE systems are used, soil samples should be taken to plow depth and thoroughly mixed before they are analyzed. This is necessary to insure a correct appraisal of the field's fertility.

Moldboard-plowing and subsequent mixing of the soil to plow depth may be necessary for high corn yields in years when the surface soil is extremely dry and plants are obtaining the majority of their phosphorus and potassium from lower depths.

THE END

Table 3. — Average Soil Test Values for Samples Taken at Three Depths, 1969

Tillage treatment	0–3 inches			3–6 inches			6–9 inches		
	pH	P	K	pH	P	K	pH	P	K
		lb. per A.			*lb. per A.*			*lb. per A.*	
Disk, moldboard-plow, cultivate, harrow, plant	5.67	58.2	340	5.57	58.8	298	5.43	42.8	277
Disk, chisel, cultivate, plant . . .	6.10	104.0	487	5.48	52.2	262	5.23	37.8	246
Disk twice, harrow-till, plant . .	5.92	59.7	332	5.30	36.2	218	5.10	31.3	201
Rotary-till twice, plant	5.98	70.2	366	5.68	50.2	254	5.30	29.5	210
Chop stalks, till, plant	6.00	71.7	425	5.25	37.5	216	5.07	29.5	204



WE ARE A SEARCHING generation. We search for peace. We search for economic stability. We search for solutions to crime and drug abuse, to pornography and pollution. And in the quest, we bicker much and agree little.

We want to "return to nature" and at the same time to heap our table with the most nutritious, CONVENIENT food man has yet known. And we want to eat it in air conditioned comfort while two cars wait our bidding in the carport.

To endure such pleasures, we allegedly take more pills than any previous generation. The current headache is pollution. In recent months, American agriculture has been called to the stand.

The Potash Institute of North America has served agriculture a long time—as long as the Soil Conservation Service. And with the same convictions as SCS—that the land must be used to serve man, not abused nor coddled to destroy him.

For this reason, the Potash Institute begins here a series on **FACTS FROM OUR ENVIRONMENT.** The series will condense the latest thinking of competent scientists in talks and reports reaching Institute desks around the nation. Each scientist is clearly identified with his viewpoint. This is the thinking of dedicated men, searchers and finders of truth—the kind of men BETTER CROPS magazine has featured for nearly 50 years.

Every effort has been made to capsule, to paraphrase, and to quote directly without distorting original content. This series is designed to help people understand the role of agriculture in our environment.

We hope **FACTS FROM OUR ENVIRONMENT** will do this—in a simple question and answer style designed for even the busiest person.

Illustration courtesy Journal of Soil and Water Conservation by Felix Summers.

FIRST IN A SERIES

Someone told me crop farming helps clean our air. How?

Fertilizers give a hand to the photosynthetic process on our farms. This helps ''maintain the oxygen-carbon dioxide balance in the atmosphere,'' explains **Dr. George E. Smith, Director of Missouri's Water Resources Research Center** and veteran agronomist. This O and CO_2 balance—vital to human survival—is disturbed by so much fossil fuel burning, as well as roads and buildings replacing green plants. **Dr. Smith** reports the farmer's remarkable contribution to cleaner air in this way: An acre of corn producing 100 bu. grain REMOVES 7-8 tons of carbon dioxide and ADDS 5-7 tons of oxygen to our atmosphere—enough oxygen to keep 12 people breathing for a year. If the corn is fertilized to get 150 bu/A, you can add 2-4 MORE tons of oxygen and 6 MORE people for a year. **Dr. Smith** asks, ''Can any other industry make such claims for cleaning the environment?''

What is the ''image'' of agriculture in the public's mind?

Mixed, according to **Dr. Sam Aldrich, prominent Illinois agronomist and member of the Illinois Pollution Control Board.** Poor in some places. Indifferent in other areas. Understood by some. Appreciated by a few. ''Ecologists generally view farmers, agribusiness, and agricultural scientists as interested only in profit . . . with little knowledge or concern for environment or even human health.'' Agriculturists feel their greatest contribution to mankind is high quality food at reasonable price . . . through efficient production . . . often in the face of some ecologists who don't understand agriculture or the disasters some of their ''solutions'' could cause.

How do most people view pollution and environment today?

Dr. Aldrich has found these six attitudes: Fear of today and tomorrow . . . faulty knowledge of the cause, seriousness, and solution to many problems . . . minds already made up on what should be done . . . no idea of the cost behind their solutions . . . poor image of farmers, agribusiness, and agricultural scientists . . . growing power to regulate the use (and abuse) of the environment.

What is the most serious pollution threat facing the world?

"People-lution," **Dr. Earl Butz, vice president of the Purdue University Research Foundation,** told an educational conference in Spain. He drew startling pictures of the world's exploding population:

- During Christ: 250 million . . . Fifteen centuries later (1600): 500 million . . . Three centuries later (1900): 1.5 billion . . . Two-thirds century later (1970): 3.5 billion . . . One-third century later (2,000): 7.0 billion (reliable estimates).

Significance 1: It took 1,850 years to reach 1st billion . . . 80 years to reach 2nd billion . . . 31 years to reach 3rd billion. NOW the 4th billion is due in 1975 . . . the 7th billion in 2,000. THEN doubling time may be about 23 years.

Significance 2: The population of the earth could conceivably increase as much in **30** years as it did in the past **30,000** years.

Significance 3: If that first 250 million had multiplied at PRESENT rate, there would now be over one million people per SQUARE FOOT of earth surface—a crowded condition.

Significance 4: If the present rate continues for just 100 years, the earth will contain 50 billion humans—1,000 people per square mile or more dense than New Jersey—over every inch of land, including ALL mountains, deserts, and both polar ice caps.

Can the whole world be made as productive as the U.S.?

The American people have certainly tried—since General Marshall offered his plan in 1947. They have made available BILLIONS of dollars (in cash and talent) to the world's developing nations . . . trying to help people help themselves. **Dr. Butz** urges us to keep some trends in sight: 72 million more people added to the world this year . . . next year more . . . the year after that still more . . . while TODAY "half the world is underfed, underclothed, undersheltered." If we find it hard to feed these people, he asks, can we catch up with that population growth? Yet, Purdue's dynamic world leader will not accept the idea that there is "no way out of the problems we have created." He admits there are risks involved, but "none so great as the risk that we may quit risking" . . . none so great as the belief that "this world is as good as it can be." Such men will never let us stop trying to make it better.

Could modern agriculture continue to produce adequate amounts of safe and wholesome food without chemicals and antibiotics?

NO! But **Dr. Butz** has an alternative: "We can go back to organic agriculture in this country if we must. We once farmed that way—75 years ago. We know how to do it. **But before we move in that direction, someone must decide which 50 million of our people will starve.** We simply cannot feed, even at subsistence levels, our 205 million Americans without a large production input of chemicals and antibiotics."

What do the romantics mean by "coming to terms with nature"?

Dr. C. H. Wadleigh, distinguished science advisor to the Administrator of the USDA Agricultural Research Service, calls it "romantic nonsense" . . . leading ultimately to a Tarzan life among the apes. He cites the early age of man when one little family needed 10 to 20 square miles to spear the wild game and find the wild roots and fruits to keep them alive. Winston Churchill once calculated all of southern England would support barely 800 of these families. They were on "terms" with nature all right, but she had the better part of the "terms." **Dr. Wadleigh** believes some of our "romantics" might enjoy such a life "provided they could also have hot and cold running water, color TV, and two cars with which to explore the environment."

Why is agriculture so important to man?

It was his first industry . . . probably launched in the foothills of Iraq, **Dr. Wadleigh** reports. He cites prominent anthropologists who have searched the evidence of man's great step from "just a hunter and food-gatherer to a food-producer." This early man had to learn one thing: "some control over nature." And since then, the history of agricultural production has been one great drama of man's desperate struggle with nature: devastating floods, desolating droughts, ravaging pests and diseases, destroying winds and frosts—and poor soils killing the spirits of men.

What ONE thing does the urban life we know today depend on?

A surplus of food, **Dr. Wadleigh** reminds us. He reports anthropologists call this "the one absolute requirement for the development of urban civilization." What happened to the fabulous cities of Mesopotania, so prosperous, so sophisticated, so self-assured 5,000 years ago? Farmers caused them by developing a relatively efficient irrigation agriculture. When salinity and sediment conquered the farmers, those cities died. And ages later anyone trying to locate them had to dig through layers of sediment. They came to terms with nature, all right, and disappeared.

What is the potential for agricultural pollution?

It is awesome when you consider the figures **the University of Maryland's Dr. Fred Miller** gave a Massachusetts dairy meeting: American agriculture has the capacity EACH YEAR to "produce, concentrate, move, and apply 40 million tons of fertilizer material, produce 2 billion tons of animal wastes, apply thousands of pounds of pesticides, occupy more than 1.3 billion acres, and cultivate over 300 million acres."

What specific steps may pollute in this massive move?

Dr. Miller cites 10 potentials: (1) sediment, (2) plant nutrients, (3) animal wastes, (4) raw ag-product processing wastes, (5) rural domestic wastes, (6) inorganic salts and minerals from irrigation, (7) pesticides, (8) aeroallergens and infectious agents, (9) particulate and gases from waste combustion, and (10) natural plant emissions. The miracle is the minimum pollution and maximum efficiency this food-growing giant has brought to the land—not to mention enhancement in many areas!

Is pollution one of man's newest sins?

Not by any means. **Dr. Miller** reminds us of Sophocles and Cato both warning of erosion and sediment from plowing and deforestation 4 centuries before Christ . . . China's Buddhist culture denuding thousands of acres to build wooden structures when other materials were available . . . Bible descriptions of the Cedars of Lebanon on a very different landscape from today's barren hills . . . Rome's early grid system of land surveying still deterring today's conservation practices.

Is man the only polluter? What about nature?

She's the worst. **Dr. Miller** and others cite some of this action:

- Just three volcanic eruptions in the past 100 years ejected more smoke, dust, and gases into the atmosphere than ALL OF MAN'S ACTIVITIES COMBINED up to the present. Take one East Indies explosion of 1883: about 70 billion cubic yards of rock, dust, and ash into the air . . . more than 20 miles into the stratosphere . . . covering the Northern Hemisphere with a dusty haze that turned sun and moon blue, purple, and green . . . blanketing Europe 3 months later . . . decreasing solar radiation 20% at first . . . holding radiation 10% below normal 3 years later . . . dropping world temperature 1° F average.

- More than 40,000 tons of sediment flow into Lake Meade behind Hoover Dam every day, most of it from natural processes.

- Eutrophication (nutrient enrichment) of our rivers and lakes is a natural process—cycling nutrients and salts through vegetation that decays into the soil to leach and run off into rivers and eventually supply the oceans with 30,000 ppm of salt. The eutrophication process created all the coal, oil, peat, and muck bogs of the world long before man made a dent on the earth.

- A year's rainfall can add 3 to 8 lbs. of nitrogen per acre. Rainfall alone percolating through the soil of a forested Ozark watershed could account for the 6,000 lbs. of nitrogen Missouri's Big Spring discharges **daily** . . . while thousands of people visit its mineral water.

- Minnesota's 7.5 million acres of peat, containing 100 million tons of nitrogen, were formed (through eutrophication) long before man settled in the area.

- Wisconsin's Green Bay was called that because the first settlers found its waters full of green algae.

- Natural springs feeding Arkansas and Red Rivers carry 17 tons of salt per minute . . . New Mexico's Lemonade Springs 900 lbs. of sulfuric acid per million lbs. of water . . . a Colorado spring 8 times the radium level called safe by the Public Health Service.

- Fish preserved for decades were recently tested and showed mercury . . . naturally, scientists say. Mercury is in soils, rocks, organic matter. It may show up to 20 ppm in crude petroleum . . . up to 300 ppm in anthracitic coal . . . up to 500 ppm in some natural tars . . . 1 ppm in most soil organic matter . . . over 1 lb. per acre in soils to a depth of 3 feet.

- More than 40 species of algae can fix nitrogen from the air and add to nature's eutrophication.

- Perhaps as high as 99% of the plants and animals that ONCE lived on this planet are NOW extinct.

What are the major sources of nitrogen in the U.S.?

Dr. Sam Aldrich gives these estimates:

	Million tons per year	Percent
Released from soil organic matter	20	37
In livestock manure	10	18.5
Fixed by soil organisms (20 lb per acre)	10	18.5
Added in rainfall (5 lb per acre)	5	9
Fertilizer (estimated for 1970)	7	13
Human waste (.05 lb N per person per day)	2	4
Total	54	100

Which of these sources may increase nitrates in water?

Dr. Aldrich cites four of them: (1) N fertilizer, (2) N released from soil organic matter and humus, (3) animal wastes, and (4) human wastes. Other sources—from rainfall and soil organisms—are believed to be constant.

Why is nitrogen in animal wastes not considered an original source?

Because it contains only N that was in crops or pastures, except for a small amount of urea additive, **Dr. Aldrich** explains. If the livestock had not eaten the crops, the N would have been returned in crop residues.

Why is the largest source of available nitrogen from plant residues and soil humus?

Because plowing, harrowing, and cultivating soil speeds the release of N in humus and in fresh plant residues. Last year the U.S. released about three times more N from the native soil supply than it applied as nitrogen fertilizer. Yet, this release rate is not nearly enough to maintain crop yields or soil productivity.

Though it represents only 13% of the total, why is nitrogen fertilizer so important?

It's the margin between adequate food and shortages for a mushrooming population. It's the key to "maintaining organic matter of intensively farmed soils," **Dr. Aldrich** explains. "If organic matter is allowed to decline because of inadequate nitrogen as it has over the past 100 to 200 years, future generations will have increasing difficulty with floods, erosion, and sediment pollution."

What about getting our nitrogen from composting plant residues?

Composting can serve the home gardener using leaves and lawn clippings, as **Dr. Aldrich** explains. But it offers nothing to farmers. Why? Because they are already using residues in the best possible way by leaving them on or working them into the field where they were produced by the preceding crop.

Can animal manure increase the overall supply of nitrogen for crops?

No. **Dr. Aldrich** explains it this way: "Animal manure contains only nitrogen that was contained in a previous crop. Hence applying manure can only enrich one field by robbing another. Incidentally, producing animal manure itself presents major problems of pollution control."

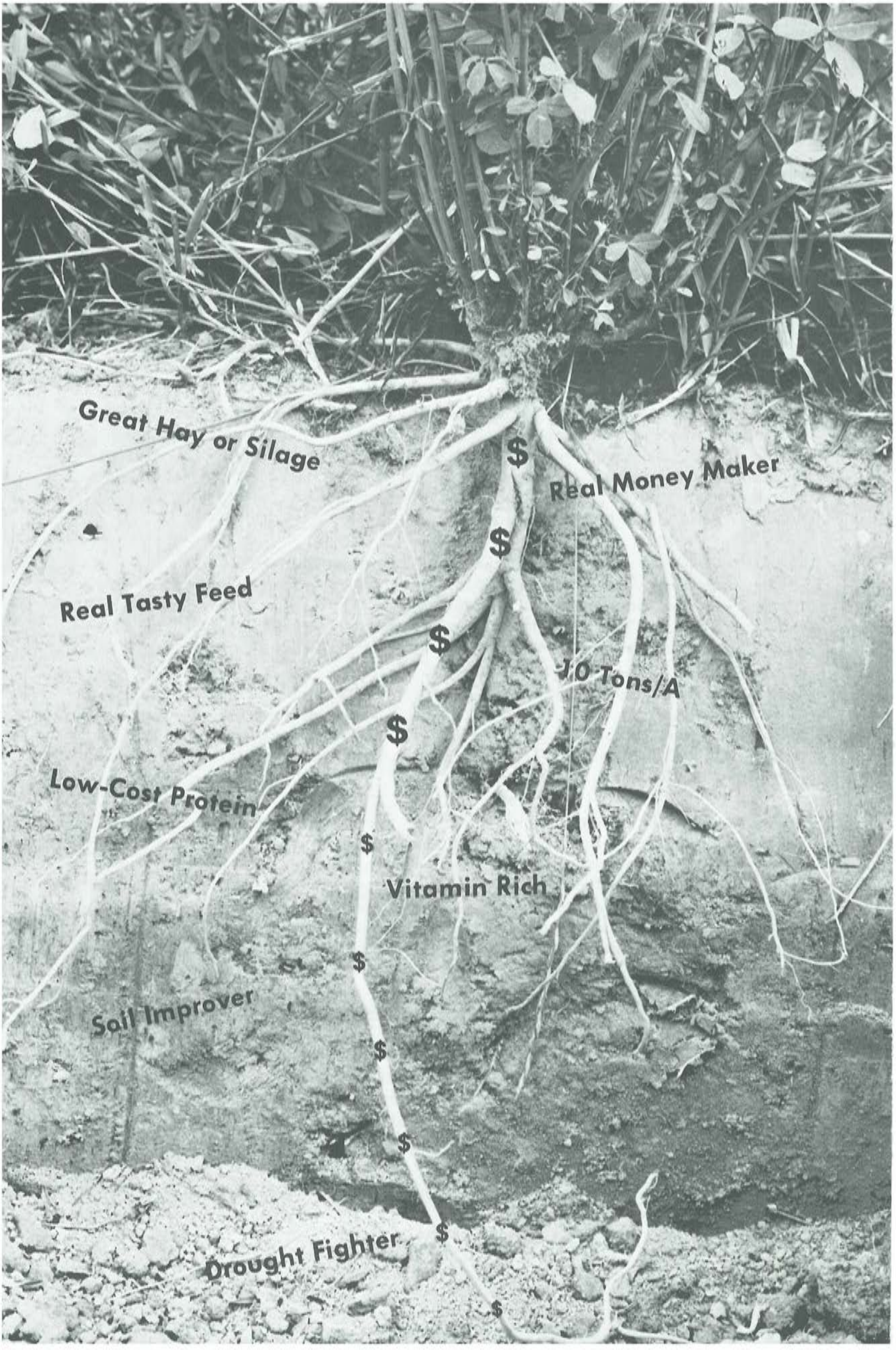
Could we cut down on nitrate flow to water by using legumes to get our nitrogen?

Those unfamiliar with agriculture and soil reactions like this idea—replacing nitrogen fertilizer with legumes that capture nitrogen from the air through bacteria on their roots. But **Dr. Aldrich** warns, "There is little if any reason to believe the amount of nitrates that gets into water would be any less from legumes or manure than from nitrogen fertilizer **to produce the same crop yield.** Nitrogen from plant residues and manure is first converted from organic form to ammonium and then to nitrate. Nearly all nitrogen in fertilizer is in ammonium form and it, too, converts to nitrate."

Is nitrogen from decaying organic matter more efficiently used than fertilizer N?

Some think so because organic matter releases its N mainly during the crop's rapid uptake while most of the nitrogen in fertilizer is all available over a short period, perhaps in excess of crop need. **Dr. Aldrich** says there is some scientific basis for this reasoning. But he points out the control a grower has over fertilizer nitrogen. Fertilizer N can be applied just before maximum crop need, while nitrogen from residues will release nitrates whenever temperature is above freezing—regardless of crop need.

TURN TO PAGE 18



Great Hay or Silage
Real Money Maker
Real Tasty Feed
10 Tons/A
Low-Cost Protein
Vitamin Rich
Soil Improver
Drought Fighter

Why should I grow alfalfa?

1. Most productive legume forage crop. 10 tons of hay per acre are being produced.
2. One of the most palatable crops.
3. Alfalfa produces more protein per acre than any other agronomic crop. As much as 3,000 lbs. of protein per acre may be produced.
4. It is a low cost source of protein in rations of high-producing dairy cows.
5. It is well suited to either short or long rotations.
6. Alfalfa can improve soil productivity. Its ability to fix large amounts of nitrogen from the atmosphere and the effects of its deep, penetrating root system loosening up the subsoil contribute to top yields of crops which follow alfalfa in the rotation.
7. Excellent for hay and/or silage. The value of alfalfa must be based on its high protein content. Therefore, a twelve ton per acre yield of 18 percent protein, low moisture alfalfa silage, is worth almost $70.00 more per acre than 20 tons of 30 percent dry matter corn silage.
8. Alfalfa contains the highest amount of calcium of all home grown fields, excels in Vitamin A and rich in Vitamin D and other vitamins.
9. Alfalfa is drought tolerant. It out-produces other legumes in a dry year.
10. Alfalfa is a money maker. Recent research is pointing the way to protein production from alfalfa of 3,000 pounds or more per acre. Based on a price of 10 cents per pound for protein in soybean oil meal, this is worth $300.00.

THE WILLCHEM COMPANY

FROM PAGE 15—FACTS FROM OUR ENVIRONMENT

Could we run into problems trying to meet our nitrogen needs with legumes?

Yes. **Dr. Aldrich** cites three big ones: (1) At least 50% more crop acres to grow the legumes and small grains for seeding them and to make up for lower acre yields on less productive soils than now farmed in a typical midwest state like Illinois. (2) Increased runoff from plowing up many steep slopes to raise these additional legume crops. (3) Destruction of millions of acres of wildlife habitat.

Is there a connection between water quality deterioration and increased fertilizer use?

Circumstantial evidence seems to say there ought to be, but positive evidence is hard to find, according to **Dr. Frank Viets, Jr., research scientist with the Agricultural Research Service of USDA, Fort Collins, Colorado.** He explains it this way: "Categorizing agricultural inputs of nitrogen and phosphorus to water by source—fertilizers as opposed to erosion of cultivated land, concentrated animal wastes, and normal nutrient outflow from land—is very difficult. Over-use of nitrogen fertilizers does contribute nitrate to groundwater, but known instances are rare.

What is one of the biggest hazards to water quality?

Sediment, in **Dr. Viet's** opinion. He explains that "sediment and nutrients in water interact with each other in many ways that are poorly understood. Thus, it is hard to neatly categorize them. Furthermore, nearly every lake, stream, and watershed is different. To generalize from the Potomac River to Lake Tahoe is impossible."

Who first warned of soils "running off" cultivated fields into streams?

Very likely Eugene Hilgard . . . State Geologist for Mississippi in the 1850's . . . and "now recognized as the most distinguished soil scientist this country has produced," according to **Dr. Wadleigh.** He developed the science of soil classification as we know it today . . . evaluating soils according to geological origin and native vegetation they produced. His warnings about rich cotton-producing soils running off came true . . . as great gullies formed . . . and sediment delivery approached 1,000 tons per acre per year. Then, many years later, agriculture woke up and started saving the soil . . . as the soil conservation crusade began. Today some classic examples of conservation farming occur on rolling hills where sediment delivery once exceeded 100 tons per acre each year. **Dr. Wadleigh** sums it up right, "The improvement in the quality of the environment is too obvious to warrant further comment."

How great is the nation's sediment production?

An estimated 4 billion tons yearly . . . from natural sources, agriculture, urban areas, construction sites, highways, etc. **Dr. Miller** cites **Dr. C. H. Wadleigh** in estimating this massive sediment loss. Sediment from **natural sources** 30% . . . from **agriculture** at least 50% . . . **from urban, construction,** and **highway areas** up to 10% . . . carrying more than 50 million tons of primary nutrients with them.

That's too massive to grasp. What about a specific river?

The Mississippi will tell you. It carries more than 500 million tons of sediment into the Gulf of Mexico every year . . . containing about 17 million tons of primary nutrients . . . **Dr. Wadleigh** reports.

How much nitrogen and phosphorus is that?

Around 500,000 tons N and 750,000 tons P_2O_5 . . . not to mention 7.5 million tons K_2O, 5.4 million tons Ca, and 2.4 million tons Mg . . . cited by **Dr. Miller.** If potash (K_2O) were an active pollutant, which it is not, its huge part in this sediment traffic could be a problem. Instead, it's just lost to the land and must be replaced by nature or man.

Why is potassium never mentioned with water quality problems?

Because it has "little involvement in water quality," **Dr. Viets** explains in a note to BETTER CROPS. "But K, like any nutrient needed for crop growth or vegetative cover, reduces eutrophication through reduction of erosion and reduction of land needs for crops having high erosion hazard," he concludes.

What determines the nutrient load of sediment?

The type of soil, greatly. Rich Midwest prairie soil carries much more nitrogen and phosphorus than red-yellow podzolic soil in the Southeast. **Dr. Viets** emphasizes research has clearly shown "eroded soil contains more nutrients than the soil that remains." **H. F. Massey** and **M. L. Jackson** reported eroded material from four Wisconsin locations contained much more nutrients than the soil that remained: 2.1 times more organic matter, 2.7 more nitrogen, 3.4 more soluble phosphorus, and 19.3 times more exchangeable potassium. **N. L. Stoltenberg** and **J. L. White** reported similar results from Indiana.

Why do we know so little about fertilizer losses?

Because we have concentrated on thousands of trials during the past 30 years to find the need for fertilizers and how much and when to apply them . . . to get more food . . . **Dr. Viets** explains. And before that—for six decades ending 1940—we ran long-term rotation experiments, such as the Jordon, Sanborn, and Morrow plots. But we rarely learned how much of the fertilizer runs off, is carried off on eroding particles, or percolates below the root zone. No balance sheet was kept of INputs and OUTputs of nutrients applied to a cropping system over a long period. By INput, **Dr. Viets** means a summary of nutrients applied in fertilizer, manure, and precipitation. By OUTput he means removal of crops, runoff, deep percolation and changes in total nutrient quantity in the soil.

What would happen if we restricted fertilizer use?

Dr. Viets expresses his view very clearly, "I am convinced that arbitrarily restricting fertilizer would be a national disaster." He used the latest Census of Agriculture figures available (1964) to estimate what could happen to just a few crops in a few states if fertilizer were banned:

In Colorado, 28.5% more acres (94,304) to get the same corn crop.
In Texas, 28.7% more acres (1,575,000) to produce same amount of cotton.
In Kansas, 20.3% more acres (1,800,000) to maintain same wheat production.
In Iowa, 29% more acres (2,933,000) to get the same corn yield.

Which way should we go: (1) More land less fertilized or (2) Less land more fertilized?

Dr. Viets urges us to increase fertilizer use on our better land where erosion hazards are least so we can retire more land where erosion hazards are great. Moderate fertilizer rates will maintain the cover for controlling erosion on the retired land. Intense fertilizer rates, geared for minimum percolation losses, should get the food and fiber we need from minimum acreage of cultivated land. The goal: to keep land with high erosion hazards in grass and forest. He emphasizes fertilizers are essential to produce vegetative cover needed for erosion.

Is fertilization the answer to erosion?

Not the whole answer. TOTAL erosion management is vital. **Dr. Viets** warns that intensified fertilization can have one of TWO effects: (1) IF runoff and erosion occur, you have enriched the sediment in N and insured more P on the dislodged soil particles. (2) IF fertilization produces better vegetative growth, you have reduced runoff and erosion enough to NET much less nutrient loss.

What point do some ecologists fail to mention about fertilizer?

How it has helped us reduce the acres it takes to fill our food, feed, and fiber needs. In 1944, when fertilizer use was still relatively low, we needed 352,860,000 acres to harvest enough crops for 138 million people, **Dr. Viets** reports. Nearly 25 years later, we needed 58 million LESS acres (294 million) to harvest enough crops for 198 million people. Fertilizer played no small role in giving new high-yield crops and technology the boost they were born to take.

Can we return to the "good old days?"

Not if we want to continue to eat. It's amazing the amount of organic matter we have lost from our cultivated soils in 100 years—some 35 billion tons containing 1.75 billion tons organic nitrogen, according to a **George Stanford** estimate. **Dr. Viets** estimates an Iowa prairie soil once producing 50 bushels of corn without fertilizer could "probably produce only 35 bushels now . . . but with fertilizers, it can produce 150 bushels."

Is the organic gardening movement a new idea?

Some may believe they discovered composting and mulching. But Homer reported manuring of vineyards 600 years before Christ, **Dr. Robert L. Carolus, Michigan State University horticulturist,** reminds us. Theophrastus classified manures by crop producing values in 300 B.C. . . . Cato advised burning vine prunings on the spot in 200 B.C. . . . both Virgil and Pliny recommended legumes and burned lime to correct acid soil in 50 B.C. And 2,000 years later our U.S. Soil Conservation Service pushes the use of plant refuse, green manuring, legumes and cover crops in rotation. Scientific agriculture has always hailed the benefits of organic matter.

Can organic farming feed all mankind?

No! Most biodegradable refuse available to gardeners (leaves, straw, weeds, sawdust, wood chips, dung, garbage, etc.) is so low in nitrogen, **Dr. Carolus** explains, that soil organisms must use most of the available soil nitrogen as they multiply to decompose the added organic material. This causes temporary nitrogen deficiency for a growing crop unless nitrogen is applied when these materials are used. You get barely 3 or 4 lbs of nitrogen out of a ton of dry sawdust or straw, only 12 lbs out of a ton of fresh cow manure.

Is that why crops grown "the organic way" in some overpopulated areas are poor and pale?

Certainly one reason. Often creating emaciated people. **Dr. Carolus** explains local varieties of rice, wheat, and other crops in these areas have "adjusted, through centuries of natural selection to low nutrition . . . responding little to fertilizer." But recently released varieties, introduced by Nobel winner **Norman Borlaug** and others, respond to fertilizer with 4 to 5 times the yield increases of local types—yields of much more nutritious food. Japan has reached "food self-sufficiency" by using more fertilizer and pesticides per hectare than any other Asian country. Her rice yields are highest, her young people are growing taller than their parents, **Dr. Carolus** reports.

Why do organic gardeners avoid highly available fertilizers?

For two reasons perhaps, according to **Dr. Carolus:** (1) The strength of modern fertilizer, sometimes containing over 50% available nutrients. They fear its potency—though **Dr. Carolus** compares it to electricity, to be used carefully and expertly. (2) An almost medieval belief that nutrients from organic materials are different "somehow" in their functions, values, or effects from nutrients in fertilizer. Such views repudiate a century of tests run by competent nutritionists, crop physiologists, and soil scientists, **Dr. Carolus** reveals. **On one hand,** high yields of highly nutritious tomatoes have been "repeatedly produced in water culture experiments with only inorganic chemicals." **On the other hand,** low yields of vitamin-hungry carrots have been grown on organic soils not supplied a deficient nutrient in inorganic form.

Do fertilizers impair soils or reduce crop productivity?

No. **Dr. Carolus** cites the oldest agriculture experiment station in the world, at Rothamsted, England. Among their 98-year records, you'll find wheat yields averaging 6% higher from annual applications of high nitrogen fertilizer than from 14 tons barnyard manure per acre. Without fertilizer, Illinois corn yields would fall 37%, Alabama vegetable yields 55%, and Florida grapefruit yields 94%, **Dr. Viets** concluded through computed data. Without pesticides, the world's food supply would fall far short of present needs, **Dr. Carolus** warns.

Are agricultural chemicals detrimental to health?

Perhaps the best answer is given by **Dr. Carolus**: "Life expectancy in the United States has increased from 62.9 years in 1940 to 70.5 years in 1968!" During the same period, wheat productivity increased 156%, corn 142%, potatoes 190%, tomatoes 260%. While prolonging life and increasing yields, we were also improving quality enough to grow a chicken today on 50% less feed, beef on 33% less feed than in 1940, **Dr. Carolus** reports. Today one dairy cow replaces yesterday's two cows. Today one agriculturist can feed four times the people he fed in 1940.

Is organic gardening the answer to a better environment?

"No," **Dr. Carolus** warns. "We have passed the point of no return to nature's way except as a hobby or recreation or therapy for a few people." He says we'll need to keep researching for new practices and varieties and chemicals that will keep our food supply ahead of our population.

How much of our food supply is due to fertilizer?

More than a third of our current food production can be credited to the plant nutrients in fertilizer, **Dr. George Smith** told the U.S. Senate Sub-Committee on air and water pollution.

How can we measure runoff water and sediment loss?

Our watersheds have sophisticated gauges, **Dr. Wadleigh** reports, "some with fully automated equipment involving floats to take water samples when any runoff occurs and automatically deposit these samples in containers in a refrigerated cabinet" . . . for accurate findings. He explains any phosphorus and nitrogen coming in from the watershed must be calculated in terms of water quantity running off at a specific time. Most of the runoff occurs in winter or early spring.

Are these sophisticated tools turning up anything interesting?

At Coshocton, Ohio, they are studying the nutrients coming from watersheds receiving different fertilizer levels and management treatments . . . which **Dr. Wadleigh** cites. Farmland that has received for years 40 lbs of phosphorus per acre per year lost only .03 to .06 lb of phosphorus per acre per year . . . about the same as a woodland watershed never fertilized. The flume for the woodland watershed became completely covered with algae during each summer, though its only phosphorus came from rotting leaves. Very little nitrogen was lost from these watersheds, "except for the one with a small barnyard."

Will a GROWING crop prevent leaching losses of nitrogen?

It seems to help, according to **Dr. R. F. Holt of the University of Minnesota Soil Science Department.** Lysimeter studies, he reports, have shown sandy soils kept fallow with no added fertilizer leached 8 times more nitrogen than similar cropped plots receiving 130 lbs. nitrogen per acre average each year. He concludes, "The value of a growing crop in preventing leaching losses of nitrogen cannot be overestimated."

Is there any insurance against fertilizers getting into runoff waters?

Careful incorporation in the soil, **Dr. Holt** advises. Either disked in or plowed down immediately after broadcasting. He cites experiments where greatest nitrogen losses came from fallow plots receiving lowest fertilizer rate. He also emphasizes the importance of timing the application to get greatest possible recovery of the nutrient by the crop. The ideal: application just before the crop is ready to make greatest use of a given nutrient. The reality: not always convenient or possible. Split applications during growing season may reduce nutrient losses.

What is eutrophication?

Some call it aging of water. It is the process of stimulating plants in water, sometimes leading to excessive plant growth. Increased plant growth releases more oxygen to the water. But when the plants die, the larger amounts of plant material demand more oxygen to decompose the dead plants. This extra oxygen must come from oxygen dissolved in water. When the water's oxygen supply falls below a certain level, stagnation and pollution set in.

What causes eutrophication?

The causes are poorly understood, **Dr. Viets** says. In the past 3 or 4 years, excess nitrogen and especially phosphorus have been blamed. But he refers to several authorities—**C. W. Weiss, R. F. Legge and D. Dingeldein**—who "point out that organic pollution is essential to have CO_2 needed by algae." **Illinois scientists L. F. Welch, F. A. Bazzaz, R. H. Harmeson, T. K. Hodges, B. A. Jones, Jr., F. J. Stevenson, and R. L. Switzer** reported to the Council on Environmental Quality that "not all scientists believe increased nitrogen and phosphorus alone are responsible for hastening eutrophication." Adding any essential element or growth factor—light, temperature, etc.—may boost aquatic plant growth in water that was deficient in that factor. Much more research is needed, they believe.

Why do so many laymen equate eutrophication or pollution with heavy N and P fertilization?

Because nothing fertilizes quite like fertilizer in their minds. Not too many of today's generation realize nitrogen can come to the soil through rainfall, through fixation out of the atmosphere, through mineralization of soil organic matter, through natural nitrate deposits. Some specialists believe decaying organic matter, for example, can potentially contribute much more nitrate than fertilizer.

Is eutrophication of lakes a recent problem?

No, sir. **Dr. Wadleigh** calls Minnesota "a monument to the process of eutrophication" . . . 7.5 million acres of peat bogs . . . containing 6.8 billion tons of peat carrying 102 million tons of nitrogen, 5.5 million tons of phosphorus . . . once lakes where eutrophication processes were completed hundreds of years ago . . . before settlers came to start any agricultural or industrial activity. Dr. Wadleigh concludes, "Thus we see that the pittance of plant nutrients coming from agricultural runoff is not essential for really tremendous eutrophic development in lakes."

Did agriculture ruin that moonlight cruise on the Potomac?

Don't blame agricultural fertilizer for those odors. Washington, D.C. sewage plants dump 24 million pounds of nitrogen, 8 million pounds of phosphorus into the Potomac in a year, **Dr. Wadleigh** reports. In the river below Washington, only 34% of the nitrogen and 14% of the phosphorus came from the 12,000 square mile Potomac watershed above the city between January and August of 1969 . . . **Dr. Miller** cites **J. A. Aalto and colleagues** . . . and much of that from cities like Frederick, Hagerstown, Cumberland, Morgantown, etc. . . . leaving "only a portion from agricultural sources."

DON'T OVERLOOK THE NEW 2-in-1 FOLDER
PAGE 27
A TEACHING and TELLING Tool Worth Using

"More and more irrigated corn producers are asking

Condensed from FERTILIZER SOLUTIONS Magazine
Feature By Dr. Everett Dennis, NFSA
Technical Director

THE WESTERN STATES where irrigation is the rule are usually blessed with relatively high levels of exchangeable potassium.

Yet, more and more irrigated corn producers are asking for potash in their fertilizer mix.

Both field and laboratory tests of irrigated corn leaves confirm that even with soil exchangeable potassium levels in the 500+ pounds per acre range, there are periods of critically low potassium levels in the corn plant.

Such low level potassium periods are seen to be correlated with: (1) the type of hybrid, (2) the amount of ammonium nitrogen, and (3) soil moisture.

Correlation of hybrid variety and leaf level potassium with later pith deterioration and stalk rot was carried on during the past several seasons.

In field plots where various seed companies' plants have been placed side by side, potassium levels measured with a Purdue-kit have shown a wide variation in the ability to pick up soil potassium.

Continuing observation throughout the season has shown that plants with low-potassium assimilation developed earlier pith deterioration and subsequently more stalk rot.

Those varieties that picked up potassium readily from the soil generally maintained a strong outer casing and good pith quality up to and past harvest.

Another factor involved here is that an adequate level of potassium actually gives the corn plant the opportunity to reach its full genetic potential for the silking period.

With the shorter pollen shed of modern hybrids, we need to get the silking period established as early as possible. Potassium will help the plant reach the earliest possible silking date.

With earlier silking we can be best assured of a full pollination of every ovule set on the developing ear. We need to select our variety with a potassium uptake potential in mind.

ANOTHER FACTOR in potassium assimilation by the corn plant is the amount of ammonium nitrogen found in the root zone. Very large applications of ammonium nitrogen just prior to planting keeps the potassium in the corn leaves suppressed at a lower level than when split nitrogen applications have been made.

Side dressing of anhydrous ammonia has also apparently contributed to temporarily lowering the potassium in corn leaves. Ammonia gas becomes the ammonium ion in the soil environment. Since the ammonium ion and the potassium ion are similar in size and electro-chemical charge, the roots take up the over-abundant ammonium ion in place of the potassium.

There is also the factor of induced potassium fixation as the ammonium ion pushes the potassium ions into the inter-layer space between the clay plates.

In this way the ammonium ion causes temporary fixation of the potassium making it relatively unavailable to the growing corn.

Proper selection of nitrogen source and timing of nitrogen applications can help

for potash"

WHY?

- **BECAUSE** corn hybrid varieties apparently differ in their capacity to pick up and use potash from the soil. Poor K users develop earlier pith deterioration, more stalk rot . . . good K users generally hold strong outer casing and pith quality through harvest.

- **BECAUSE** potash helps the plant to realize its full genetic potential for the silking period . . . to reach early silking for full pollination of every ovule set on the developing ear.

- **BECAUSE** heavy loads of ammonium ion—same size and electro-chemical charge as the potassium ion—can push K ions into the inter-layer space between the clay plates while the corn roots take up the abundant ammonium.

- **BECAUSE** corn growers want to bridge the "potassium gap"—that critical 8th week (June 20-30) when damaging K hunger may creep into leaf tissue as surface soils partially dry out just before irrigation.

to offset this effect on corn potassium levels. Perhaps the best policy is to use a form of product that does not carry all of the nitrogen in the ammonia or ammonium form.

Preplant nitrogen should contain two, and preferably three, forms of nitrogen. Side-dress nitrogen should obviously carry the lowest level of ammonium ion and is therefore best applied as one of the liquid nitrogen products.

If anhydrous ammonia is used, it should be applied in the fall or early enough in the spring to give time for the ammonium ion to reach a measure of equilibrium with the soil.

Corn grown on sandy soils with their low cation exchange capacities and relatively low exchangeable potassium is particularly susceptible to low leaf potassium when overloaded with anhydrous ammonia.

SEVERAL YEARS AGO Iowa researchers pointed out that drought could induce a temporary potassium deficiency.

In the irrigated areas of the west, we are becoming much more aware of pre-irrigation matric tension and temporary drought stress with its accompanying drops in tissue potassium levels.

Most irrigators along the Platte Valley of Nebraska will furrow their corn about the 20th of June and irrigate sometime before the 4th of July. **We have noticed the relationships in corn potassium levels. Shown in Figure 1.**

It is hypothesized here that those tissues laid down in the plant during the period that potassium falls below 3 percent level are subject to later deterioration and these same tissues become focal points of fungus infection.

In the field, rapid tests indicate potassium can be low in leaf tissue where surface soils have been allowed to partially dry out. But the same field shortly after an irrigation will show adequate leaf levels of potassium.

Follow up examination in the same fields during the season shows that stalk and pith deterioration begins early in these previously stressed plants.

Corn of the same variety near by, but not moisture stressed, maintains its potassium level and its pith quality late into the season.

If we consider the weeks just before irrigation in terms of the stage of plant development, we will see that the period around the 20th of June is a critical period

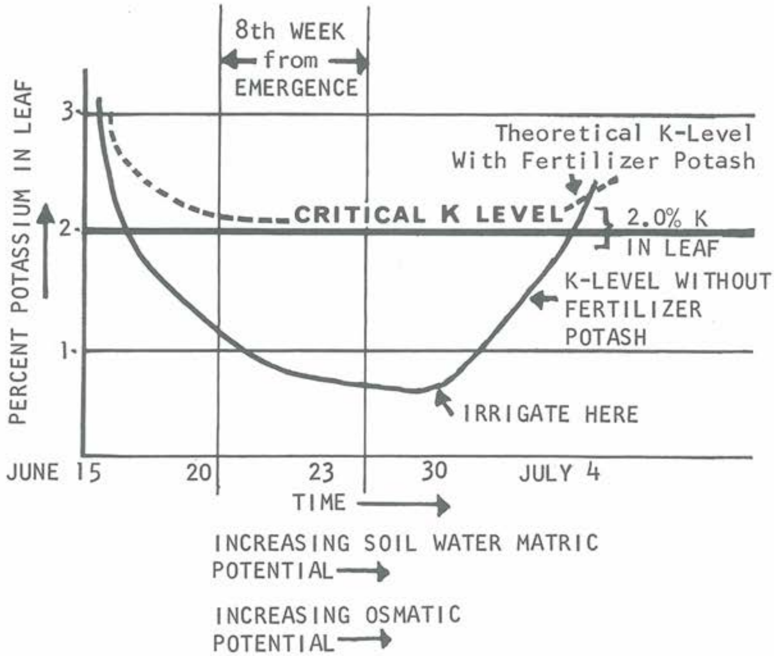


FIGURE 1

in the life of the corn plant as far as yield is concerned.

Many corn growers have come to understand that the yield potential of a corn plant is established by the eighth or ninth week.

Beyond that time whatever we do to the corn field is by way of a salvage operation to try to save as much of that potential yield as we can.

Let's examine the early growth of a corn plant from the point of view of its changing physiology. Since the early ear development is critical in determining the yield, let's look at that period:

- **The young ear shoots begin to develop sometime about the fifth week after emergence. Potential ears develop at each of 5 or 6 nodes and usually, if the environment is favorable, the topmost shoot becomes the fully productive ear.**
- **The number of rows is selected and fixed very early in the development of the ear. Also, by about the eighth week the ear begins to set the number of ovules or future kernels. This period is therefore critical in determining the size and yield potential of the ear.**
- **Either moisture or nutrient deficiencies at this time may reduce the potential size of the ear and also the final yield. (It should be understood that the actual "time" of events in early plant development will depend on length of maturity of the variety, soil temperature, thermal energy units, etc.)**

If we refer again to the "potassium-time chart" we will see that this critical eighth week is usually within the period between the 20th of June and the 30th when potassium may be at its lowest.

If we irrigate earlier, we can maintain a better potassium status. Corn growers are adding potassium to their fertilizer in order to help bridge this potassium drop before irrigation.

Many corn irrigators are now splitting their potash applications, even on medium textured soils in order to keep potassium in line with their nitrogen application.

Liquid nitrogen can be mixed with a substantial amount of potassium without any problem of salting out and this mix can be pumped onto the fields through the center pivot type systems.

Sidedressing of nitrogen and combined potash is also becoming an accepted practice. Cultivators and furrowing (for irrigation) equipment are being equipped for applying nitrogen and potassium in several applications to lighter soils.

Solid set sprinklers as well as the center pivot systems are ideally set up for applying liquid nitrogen-potash combinations varying from grades such as 10-0-6 to 9-0-8 to 16-0-4.

The actual grade will depend on the texture of the soil, the exchangeable potassium, the exchangeable magnesium and the capabilities of the sprinkler system.

The nitrogen and potash are put through the systems from the early weeks in order to build a soil nutrient environment that assures the full potential of the developing ear.

THE END

NEW Two-In-One FOLDER

Soybeans, long called the wonder crop, have an appetite that's also a wonder—an appetite that doesn't always get fed at the second table after corn.

A new brochure featuring university research shows why. Issued by the Potash Institute of North America, the colorful folder shows step-by-step how a 50-bushel crop can take up 560 lbs. of plant food from each acre.

The story is calculated from N. C. State University data. It shows how much dry matter the crop has produced and plant food it has absorbed within 40 days, then 80 days, 100 days, 120 days, and 140 days.

It shows how the soybean plant produces about half its total dry matter in 80-90 days after planting. As yields increase, more of the total weight percentage shifts from vegetation to seed and pod. Though greatest nutrient accumulation occurs during grain formation, early season uptake can be heavy.

Half the new two-color brochure is devoted to specific steps the farmer can take to get extra bushels per acre. It discusses and illustrates right seed selection, best planting time and rate, full-feed fertility, lower weed tax, and right combine use at harvest.

The pictures and many of the steps toward more profitable management are from the National Soybean Crop Improvement Council. It is 2 folders in one. From front cover panel it opens into UPTAKE story. From back cover panel it opens into EXTRA YIELDS story.

A sample copy can be secured by sending coupon on back cover.

"A truly balanced fertilizer

WILLIAM E. KNOOP UNIVERSITY OF NEW HAMPSHIRE

TWO FACTORS were considered in developing new fertilizer recommendations for New Hampshire turf growers:

1—We considered a significant number of soil test results, with special attention to phosphorus and potassium levels. From 270 soil tests in 1970, we got a striking picture of K need. As Figure 1 shows, 89% of the soil samples tested medium to high (about 6 to 16 ppm) in phosphorus, while 77% were low (about 70 ppm or less) in potassium. We used a modified Morgan Method.

2—We considered the nitrogen, phosphorus, and potassium levels required by the turf plant. Turf requires high nitrogen levels. In comparison, it needs relatively low phosphorus levels and moderate potassium levels for optimum growth.

For many years, our area has recommended the descending fertilizer ratio—10-6-4—for turf. With these soil test results and our knowledge of the turf plant's nutritional needs, **we believe such fertilizer—with descending ratio, such as 10-6-4—does not contain enough potassium per unit of nitrogen or phosphorus.**

Early last spring (1970), Mr. Lou Duval submitted soil samples from Manchester Country Club for analysis. **All samples from both greens and fairways tested low in potassium. This course had used low-potash turf fertilizers for years.**

Based on his soil test results, Mr. Duval agreed to apply muriate of potash at a rate of 2 lbs. per 1,000 sq. ft. over the entire course, biweekly, during April and May. Just a week following K application, he noted a darker green turf and improved growth without additional nitrogen fertilizer.

From June 1 to September 1 he applied 1 lb. of muriate per 1,000 sq. ft. every other week. Throughout the summer Mr. Duval reported **40 to 50% less wilt, less dollar spot disease and more even growth response. No growth flushes occurred when nitrogen was added.**

In September, October, and November, he returned to the 2 lbs. muriate per 1,000 sq. ft. rate, biweekly. **His course suffered relatively little winter damage.**

This year (1971) continues his program of building up potassium levels in the soil and in the plant.

Potassium nitrate is being used for the first time. Results from this fertilizer are promising.

Many other professional turf growers in our area are finding new benefits from using a truly balanced fertilizer—**one that contains at least 1 unit of potassium for each 2 units of nitrogen.** THE END

benefits turf growers . . ."

. . . when they learn and do something about their low potassium supply.

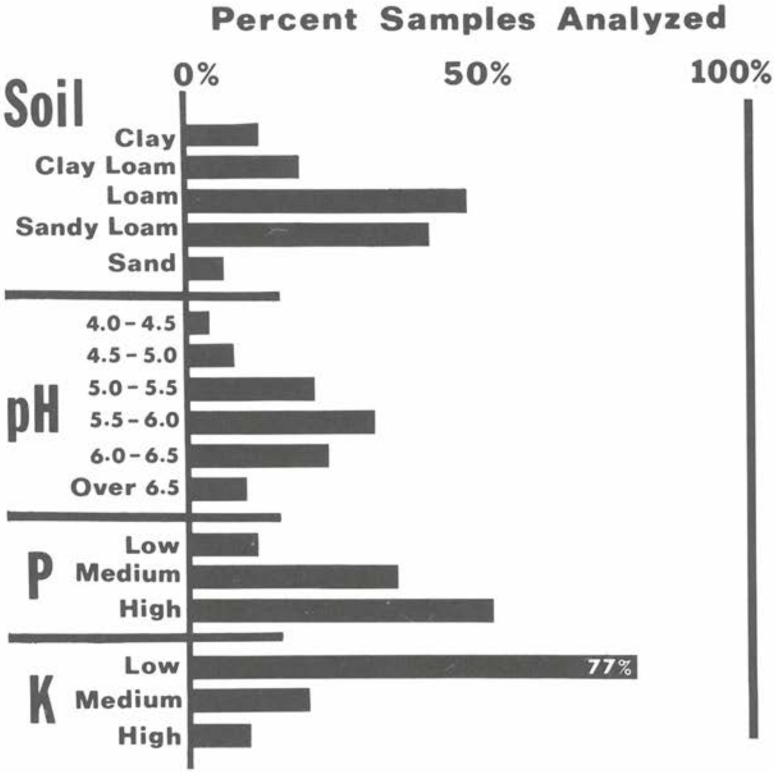
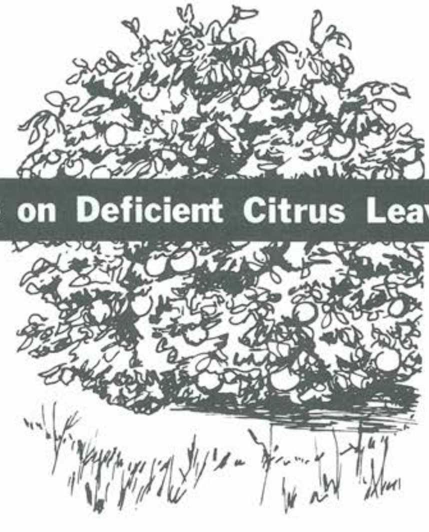


FIGURE 1



Spraying K-Nite on Deficient Citrus Leaves

MARY WILLIAMS
IN SUNSHINE STATE AGRICULTURAL RESEARCH REPORT
UNIVERSITY OF FLORIDA

FOLIAR SPRAYS of potassium nitrate have been effective in correcting potassium deficiency of citrus in the Indian River area of Florida, where potassium fertilizers may not give results.

Dr. D. V. Calvert, Associate Professor (Associate Soil Chemist) with the Citrus Experiment Station at the Indian River Field Laboratory, Fort Pierce, reports potassium deficiency is common on the calcareous soils of the Indian River area. But the condition is difficult to correct by use of soil-applied fertilizer. Apparently the high levels of calcium in the soil interfere with potassium uptake.

Symptoms of potassium deficiency of citrus trees are decreased yields and small, thin-skinned fruit with high sugar content of the juice. Research indicates maximum yields of citrus on calcareous soils in Florida are obtained when potassium content of leaves is at least 1.0% for oranges and 1.3% for grapefruit.

Studies in Florida and elsewhere indicate rind disorder of oranges known as creasing is reduced as the potassium fertilization level is increased. And, since other studies in Florida have shown that "Murcott" trees are extremely susceptible to potassium deficiency, Dr. Calvert suspected the deficiency might be responsible for the "dieback" of the Murcott variety on the calcareous soils in the Indian River area.

RESEARCH ELSEWHERE had shown some progess in increasing leaf potassium through foliar application of potassium nitrate (KNO_3). So, Dr. Calvert set up experiments to compare various rates of foliar KNO_3 as well as ground-applied KNO_3, for raising leaf potassium levels in Florida citrus.

Trials were made in four groves near Fort Pierce: 1. "Valencia" trees on Parkwood loamy fine sand; 2. "Hamlin" oranges on Parkwood loamy fine sand; 3. "Temple" oranges on Felda fine sand; and 4. "Murcott" oranges on Felda fine sand grading into Pompano sand.

The Valencia oranges received 3 different rates of KNO_3 applied at 3 different frequencies (1, 2, or 4 times at weekly intervals.) This spray treatment was in addition to the regular grove fertilization. When leaf sprays were used, the ground under the trees was covered with polyethylene sheets which drained the excess spray off into the water furrow.

Foliage sprays plus soil treatment with KNO_3 were used in the Hamlin and Temple groves. The Murcott oranges received

Corrects K Hunger

Trees sprayed with KNO_3 had significantly higher yields than the checks. Sprays also affected soluble solids content and sugar/acid ratios, but the effects were not consistent.

Spraying two times with KNO_3 was almost as effective as spraying four times. The more useful dosages were one spray at 40 pounds per 100 gallons water or one or two sprays at the 20-pound rate.

foliage sprays alone, at 2 different rates applied 3 times a year.

Foliage sprays boosted leaf potassium levels rapidly. As both rate of application and number of applications increased, leaf potassium generally increased.

THE HIGHER POTASSIUM content of the citrus leaves lasted only a few weeks, and levels had dropped back near the starting point by the end of the fourth week. Dr. Calvert says the potassium absorbed by the leaves may have been transferred to the maturing fruit or may have been diluted in the production of new flushes.

Spraying with KNO_3 at 60 pounds per 100 gallons of water caused too much leaf burn. Symptoms of burn were not noted on trees receiving the 20-pound rate of spray, and only slight burn symptoms were found on trees receiving the 40-pound rate.

The injury could not be entirely attributed to the sprays, because slight burn symptoms and leaf fall were observed on other trees in the grove which had not received a potassium treatment.

Severity of leaf injury increased with higher rates and more applications of spray. Trees receiving only one application had significantly less leaf burn and leaf drop than trees receiving more than one spraying. The burn injury caused by one application at the 60-pound rate was moderate, but the burn after two applications at this rate was great enough to be prohibitive.

IN A YEAR of moderate creasing, the Hamlin trees receiving foliar sprays had fewer creased oranges, and the symptoms that did occur were less severe.

The spray treatment also improved foliage density. Trees receiving 20 and 40-pound rates of KNO_3 had more foliage than trees in the check plots. Foliage density was less, however, with increasing number of applications at the 40 and 60-pound rates.

Trees in treated plots were darker green than check plots. Leaf analysis showed that nitrogen in sprayed leaves was higher than in check leaves. Trees receiving the higher rates of KNO_3 tended to have a moderate case of iron chlorosis.

Foliage sprays of KNO_3 resulted in significantly less "dieback" of Murcott trees, which indicated the problem may be due at least in part to extreme potassium deficiency.

A number of trees in the Murcott grove showed symptoms of dieback and defoliation, along with a yellow dullness of the foliage. These symptoms were worse on trees bearing the largest crop of fruit in the season.

Highly significant difference was found between the number of trees showing dieback symptoms in the untreated check plots and the treated plots. Trees receiving foliage spray had higher leaf potassium content, and fewer of these trees showed dieback symptoms.

Murcott trees in sprayed plots also were distinctly greener and more thrifty in appearance than unsprayed trees.

The few trees showing dieback symptoms in the sprayed plots were still in much better condition than affected trees in the check area. **THE END**

BIFOCALS

S.W. Martin

"...the ones whose

IN A DAY of miraculous chemicals insuring food for exploding populations, a "natural resources" man allegedly has lamented what he calls "the muzzling of biology and wildlife professors in universities with powerful agriculture colleges."

That quote grabbed me because I've served agricultural scientists 20 years—5 as a roving writer for a land-grant school, 15 on the news desk of a research institute run by agricultural scientists well known for pursuing truth.

They are many things—agricultural scientists—but neither muzzled nor muzzlers have I found them to be.

They have stubborn chins, stuck for decades into what Lyndon Johnson might call "the very 'myrah' of our bones"—our environment. Our soils, our food and fiber plants, the heart of our physical survival has been their job.

They are sometimes slow, tedious men. Something like Einstein with those fast young mathematicians who rushed down from Columbia to show him a new formula. He said something like, "Slow down, boys, I'm a slow thinker." But what depth!

Agricultural scientists will never be indicted for eloquence. Nor do they shout. They check and double check and check again and talk with each other—and then send a set of cautious words over to a tired ag editor to draft into language dropouts like me can understand.

Two things you can bet. The slightest morsel of knowledge those stubborn chins plow up will get the wind tested out of it. If it holds up, these scientists in the sweat soaked shirts with muddy collars will plow through any muzzlers to let the people know.

Most citizens are not interested. Why should we be? The supermarket is always open and full of food. And we haven't lost an ounce of sweat plowing, planting, cultivating, or harvesting it.

This miracle they gave us—our freedom from the sweat of the fields. Many ag scientists were born in the very bosom of our environment—on large and small farms where they early learned to court nature, not rape her. And where they usually grew strong.

Yet, there are no supermen here. Some pursue restlessly a noble thing they call "challenge"—spelled s-a-l-a-r-y and/or t-i-t-l-e by old newsmen. Some dream up certificates they can award to each other in the Faculty Center's finest dining room—and should. Some seek grants for pet projects—and should.

Some quench their thirst for prestige with occasional leaves to other institutions or nations to bask briefly as prophets WITH honor. And when they return, there is less stoop in their shoulder, more bounce in their walk, a little higher tilt to their chin. Some have a huge appetite for prestige and respect. They can starve quickly in the desert-of-colleague-contempt.

I've never understood why they don't revolt against the publish-or-perish fetish. Time needed to think and uncover a REAL gem of knowledge must be wasted, sometimes, scratching around rehashed scientific literature to grind out another innocuous "paper" for some tired little bulletin in their "field."

Why? Because the more titles—in everything from mimeographed garden bulletins to chemical society journals—the more standing. One day some land-grant college dropout, who became more interested in watching hard-pressed properties become bargains than in searching for scientific truths, will endow a university to free scientists to think more and write less.

In the scramble for acceptance by urban neighbors, most of us don't realize these ag scientists helped the American farmer produce roughly 160% more bushels of corn on 36% less land for 65% more people in 1970 than in 1930.

So what? So space for that nice

necks are red..."

golf club and community center . . . that convenient shopping mall, with adjacent hospital . . . that new quiet industry in the country between county seats . . . that comfortable parkway drive to grandma's in 3 hours instead of the twisting, sapping 6-hour pilgrimage of the 1940's.

Many ag scientists display a dedication that honors the human spirit—turning down so-called promotions to stay with a particle of clay, an ear of corn, a grain of wheat that hypnotizes them. We can thank God for them every meal.

I once worked for a university chancellor who left his lab and students to accept the elegant suite in the northeast corner and the chancellor's mansion in the beautiful grove. He took on the burdens of cogitation and agitation and manipulation that go with managing a good university and a good supermarket.

In less than a decade he had returned, by request, to his little home on the edge of town with the garden and chickens and 3-mile ride to his classroom and lab probing the mysterious world of genes.

When I learned of his return to that most important job, I wrote him a note of congratulations on his promotion. He and his ego had been to a summit and found it wanting—for him. And he had the Trumanistic courage to do something about it. No man will muzzle that scientist.

No man will muzzle the ag scientists now working on a beautiful pasture in the shadows of North Carolina's Great Smoky Mountains. Reports say this pasture has BOTH geologic and topographic capacities (a rare combination) to funnel all runoff and ground-water down to one point.

There TVA specialists are catching and testing runoff water with very sophisticated tools, to see what happens without and with fertilizer. They are not sticking a dipper into a river and shouting blames upstream.

They call results "limited," so far. Yet, shifting from no fertilizer to fertilizer has shown little difference in water, to date. A healthy crop apparently takes up the fertilizer.

My point is not agronomic, but the facts we can gain from such men. They have a proud heritage of careful counsel to the people who must coax the food from our environment—never shouting alarms or victories, but producing.

Tomorrow can depend on this kind of man—the ag scientist on his knees in a distant row peering with boyish wonder at a lower stalk, a pipe dangling stubbornly from his Indiana teeth.

I speak of the ones who have stayed with their science—who have never polished their rhetoric or social graces or shoes enough to be considered for the northeast suite or any other suite.

The ones who go to the basement cafeterias on the side streets of their annual conventions to stay within their small budgets.

I speak of those whose suits hang loose, whose collars look more comfortable than stylish. The ones whose necks are red, not from bigotry or expensive cocktails, but from dedication to hot rows of a new corn in Iowa, a new bean in Illinois, a new potato in Maine, a new runoff study in Ohio and Oregon.

I speak of those who return from convention papers delivered in fancy ballrooms to a plot of strange new grass on the edge of little Tifton, Georgia—and there alone to kneel and caress a blade.

There to think and wonder and perhaps ask for help, there alone, in what else to do to make that grass give not two or three blades, but maybe a dozen the day man needs them to survive.

Such men live with the soil and, therefore, close to the origin of man. Such men do not muzzle—and cannot be muzzled, in my judgment.

Such men will give us the truth. And I am betting the truth will not send millions of us back into blistering fields with hoes and helmets and bonnets to scratch out enough food to keep ourselves alive.

ORDER 2-in-1 FOLDER (Page 27) ON THIS COUPON

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