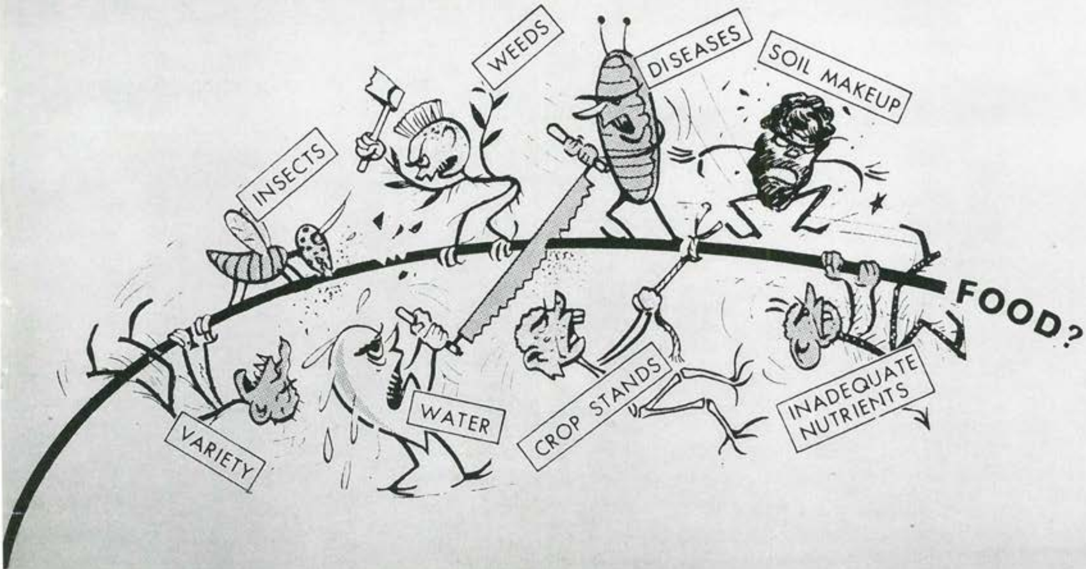
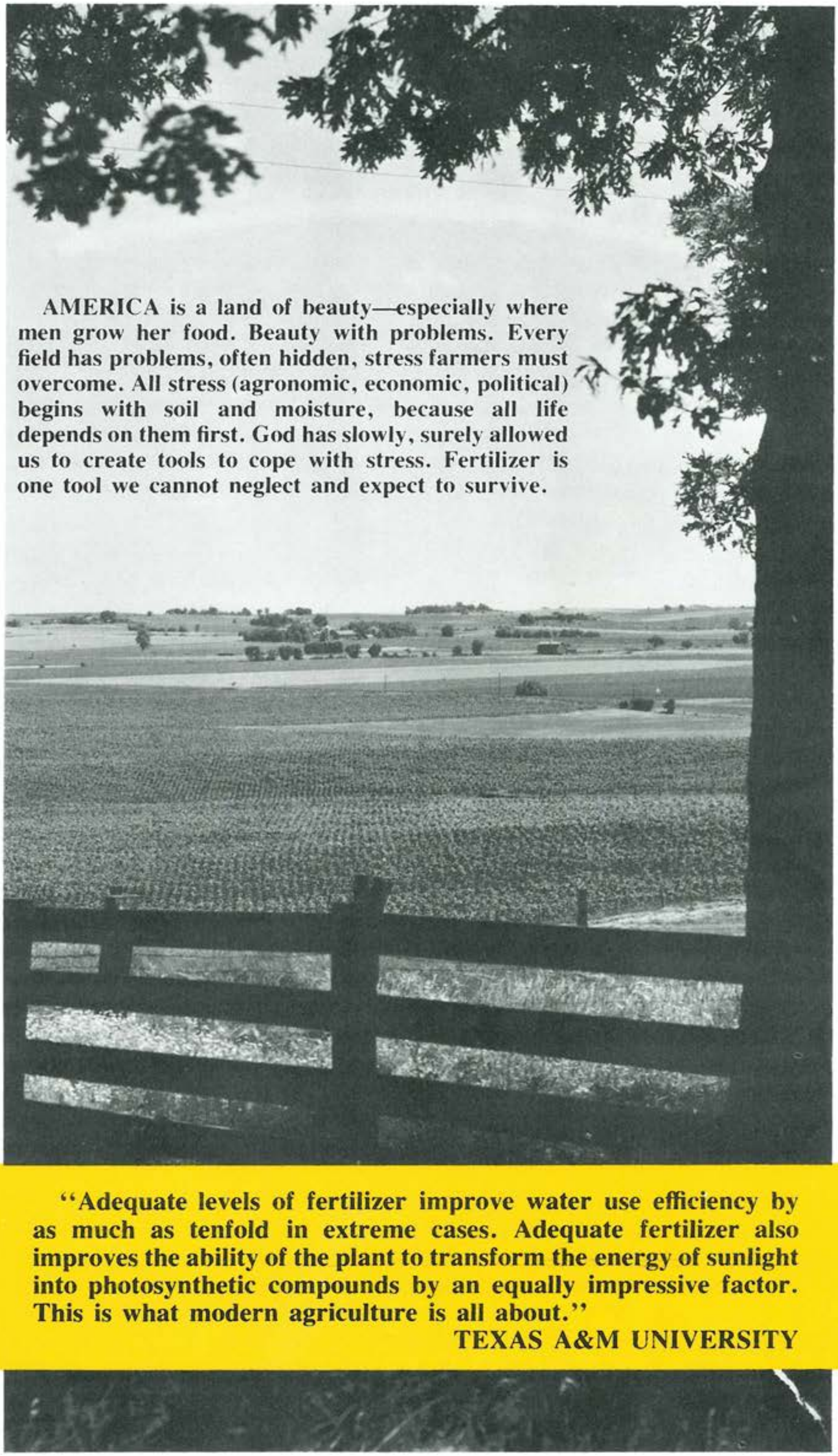



**MANY STRESSES** work to overcome man. Yet, the nearly 4 billion people on earth today have about 20% more food per person than the 2.7 billion people 20 years ago. Agronomy, the science of survival, helped farmers build this record. But stress will not let us rest on that record . . . see page 4.

# Better Crops
## WITH PLANT FOOD

NUMBER 3—1975 25 CENTS



AMERICA is a land of beauty—especially where men grow her food. Beauty with problems. Every field has problems, often hidden, stress farmers must overcome. All stress (agronomic, economic, political) begins with soil and moisture, because all life depends on them first. God has slowly, surely allowed us to create tools to cope with stress. Fertilizer is one tool we cannot neglect and expect to survive.

**"Adequate levels of fertilizer improve water use efficiency by as much as tenfold in extreme cases. Adequate fertilizer also improves the ability of the plant to transform the energy of sunlight into photosynthetic compounds by an equally impressive factor. This is what modern agriculture is all about."**

**TEXAS A&M UNIVERSITY**

**Better Crops**
**WITH PLANT FOOD**

**Published Quarterly by**
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# CONTENTS


# Crops, Like Folks, Have S-T-R-E-S-S

### 1st IN STRESS SERIES

WERNER L. NELSON
W. LAFAYETTE, INDIANA

**MANY PEOPLE SUFFER** stress today—from their environment or from the goals they set for themselves. Such stress may cause physical and mental breakdowns in some people.

Crops also suffer stress—from high yield goals their growers set or from the environment they must confront. A single factor or combination of factors can prevent a crop from reaching its full genetic yield potential.

In a high-yield environment, the same soybean variety receiving good practices may vary greatly in yield—90, 70, and 40 bushels per acre—at DIFFERENT locations in the same year. Or it may vary at the SAME location from year to year. The same can be said for corn and other crops. Why? We must find the reasons.

In a low-yield environment, stress is more easily pinpointed—such as, inadequate inputs, weak economy, little incentive, bad weather, and poor technology.

Yet, in both high-yield and low-yield environments, the goal is always the same—to reach the NEXT RUNG on the yield ladder as conditions permit.

**WHAT ARE BEST** conditions for crop growth? We often talk about optimum conditions for crop development. Those conditions are always based on what we know at that time—1960, 1965, and 1975. What about 1985? Optimum today may look primitive by then.

New research on varieties and management techniques can change our idea of "optimum conditions." The additive effects of improved practices can set our eyes on even higher yields. So far, these extra yields have always come—thankfully.

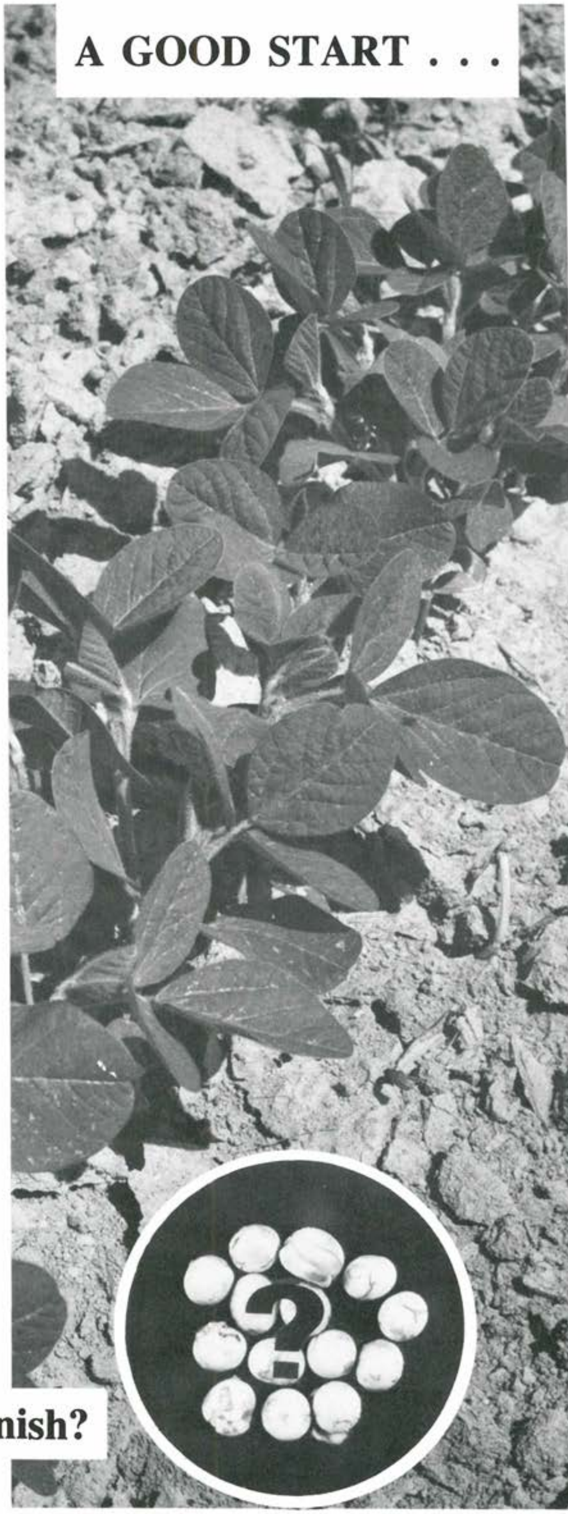
In the meantime, we must study WHY crop yields vary so much from one location to another in the same year at the same location in different years. Three growth factors can cause stress: (1) Physical, such as drouth. (2) Chemical, such as nutrient deficiency. (3) Biological such as insects.

The impact of certain stresses seems to depend on the stage of plant development. For example, a plant can endure water stress at a given stage of development and seemingly recover completely. But when the same degree of water stress strikes at a more critical growth stage, yields decline drastically.

Stress fighting is an endless battle. Remove one or several stresses to increase yields and other factors come along to put new stresses on the crop. In short season areas, plants have to make every growth day count. What a challenge—to be at work uncovering and controlling the secrets that limit plant growth.

**WHAT FACTORS CAUSE PLANT STRESS?** There are many more than these well known ones—and probably many we have not yet discovered. But these can greatly reduce crop yields.

**DROUTH.** When the soil dries, nutrients become less available. Drouth can reduce corn growth sharply. And when it hits near silking, pollen fall and silking times may not mesh very well.



Soybeans are very susceptible to drouth at bloom and podsetting. Persistent drouth at this time can reduce yields greatly.

Water transports nutrients, carbohydrates, sugars, and other products in the plant. When such crops as soybeans and corn don't get enough moisture, they can't take up sufficient nutrients or move other materials within their plant body. Wilting soon constricts passageways even further.

**EXCESSIVE WATER.** Roots breathe. They need oxygen in the soil to breathe and serve normal plant activities. Too much water sets off an interesting chain of events . . . shallow roots sometimes growing on the surface . . . weeds taking hold . . . some nitrogen loss through denitrification . . . less plant uptake of other nutrients, especially potassium.

**NUTRIENT HUNGER.** In a factory, just one missing part can stop the assembly line. In a plant, certain elements become a part of the plant structure while others act as catalysts. The deficiency of just one nutrient can cause the plant to malform and plant processes to slow down or even stop.

**NUTRIENT EXCESSES.** Soil acidity usually leads to excessive Al, Fe, and Mn. An acid plow zone is easily corrected with lime. But an acid subsoil takes long periods of surface liming to change. And we still know little about how these excesses actually affect plants, except to restrict roots and to be absorbed in high quantities.

Nutrient balance enters in. For example, high $NH_4$-N may reduce uptake of Ca, Mg, and K. Other relations to consider are P-Zn, K-Mg, Fe-Mn, and B-Ca.

**VARIETIES.** Different crop varieties may vary greatly in yields—corn as much as 100 bushels, soybeans 20 bushels, alfalfa 3 tons. Why? Because they react differently to stress—weather, soil, plant nutrients, diseases, and insects. Yet, this variation in yields may come from deficiencies in the gene makeup of the variety. That is why varieties are tested at a given location for several years to learn their yield probability, quality of product, and other traits. Frequently they are also tested at a number of locations to learn performance in different soils and climates.

**PLANT POPULATION.** The trend has been toward heavier populations in almost all crops, including corn, peanuts, and tomatoes. In heavier populations, individual plants face a much different environment of moisture, nutrients, light, carbon dioxide, diseases, and insects. Soybeans, we are finding, require thinner planting to prevent lodging of current varieties.

**ROTATIONS.** Although there has been a trend toward monoculture with cotton, corn, soybeans, wheat, and other crops, some interesting facts have turned up on Illinois' 99-year-old Morrow plots. When the corn-oats rotation (continuous corn) was shifted to corn-soybeans in 1968, corn yields started increasing in the rotation, as this table shows.

**CORN YIELD**

| Year | Continuous Corn | Corn-Soybeans | Increase |
|---|---|---|---|
| | | bu/A | |
| 1969 | 136 | 145 | 9 |
| 1971 | 146 | 169 | 23 |
| 1973 | 148 | 180 | 32 |

How much of this increase comes from carryover effects of corn-oats? How much directly from corn-soybeans? Are corn plant residues toxic to corn? Are pests building up? Research is needed to learn the "whys".

**WEEDS.** Weeds put great stress on crops—especially soybeans—by competing vigorously for water, light, and nutrients. One cocklebur every 10 feet of row reduced soybean yields 10% in Mississippi. One every 1¼ feet reduced yields 42%.

**OTHER FACTORS.** Many other factors—soil compaction, insects, diseases, nematodes, nutrient balance, temperature, light, carbon dioxide, erosion, hail or wind, herbicides—may cause some degree of plant stress and prevent it from reaching its genetic potential.

So—final yield comes from the plant's amazing integration of all growth factors.

**WHAT CAN HELP OVERCOME STRESS?** Certain approaches can help crops fight stress. Here are some examples.

**DROUTH.** Irrigating the soil almost guarantees high yields in dry regions and on sandy soils in humid areas. Small amounts of water pay well in humid areas frequently hit by summer drouths. Irrigation may add 100% more yield to one corn hybrid, only 12% to another, as Michigan reported.

Some varieties make more efficient use of water. In Tennessee, one soybean variety produced 3.1 bu. per inch of water. Another variety produced double this—6.2 bu. per inch. Differences have been found in other crops, such as wheat.

Planting corn early usually gets the crop through critical tasseling time before most drouths and gives the corn longer days. Early soybean planting helps time the fruiting period for best advantage.

Subsoiling 18 inches deep, directly under the row, helps roots penetrate compact subsoils for deeper moisture. Such states as Georgia, South Carolina, and Mississippi practice this.

Keeping high P-K levels in the soil helps increase movement of these elements to the root to fight temporary drouths. Additional K on corn added 7 days to grain filling time in Kentucky. Additional P on alfalfa increased irrigation efficiency 34% in Arizona.

**EXCESS WATER.** Some farmers will farm around a wet spot for years—or penalize the whole field by not planting until the wet area is dry enough for it. As soon as he gets a good farm, a good manager makes sure it is properly drained. He doesn't want other good management practices to "go down the drain" of poor drainage.

**NUTRIENT HUNGER.** The recent fertilizer shortage helped accentuate a problem many farmers never really conquer—nutrient deficiency symptoms, especially HIDDEN hunger, in the high-yield environments.

This hunger—seen or hidden—constantly threatens higher yields, so badly needed these days. Plant tests are one weapon to fight it. Another weapon is the "field strip"—the same area receiving extra amounts of a certain nutrient for a few seasons and closely checked for symptoms, quality, and yields.

**NUTRIENT EXCESSES.** In just 5 years, U. S. growers have reduced limestone use more than 20%. In time, this can cause two problems: (1) Declining yields. (2) Excessive Al, Mn, and Fe absorbed by plants. Researchers are now trying to breed wheat, soybeans, and other crop varieties with greater tolerance for Al, especially in the subsoil.

**VARIETIES.** Plant breeders are creating varieties more tolerant to drouth, diseases, insects, and high populations. They are striving for higher yields. How much more strain will these yields put on the soil and the environment? We need to learn the nutrient response and requirements of these new varieties.

Corn varieties are now being developed to resist cold and tolerate earlier planting much better than current hybrids. New sorghum hybrids can now tolerate the cold nighttime temperatures above 6,000 feet in Mexico and other nations.

**CHECK CROPS CAREFULLY.** Good researchers, dealers, and farmers keep a close eye on their crops—for insects, for certain nutrient deficiencies, for any problems that can be eliminated in the current season and next.

A good stand of uniform plants points to high yields. An uneven stand points to problems. Can they be corrected next year? There is no better time to start than NOW! **The End**

**These thoughts introduce a special BETTER CROPS series on stress in modern crop production. Future authors will look at specific stresses including moisture, disease, lodging, planting date, harvest date, genetics, and compaction.**

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# SULFUR FOR DAIRY COWS

**IN WALLACES FARMER MAGAZINE**

**RECENT STUDIES** at Ohio State University indicate that inorganic sulfur is more effective than either the organic form or a combination of inorganic and organic sulfur for supplementing diets of dairy cows.

Sulfur deficiency depresses feed intake in cattle. Sulfur deficiency problems are common in areas like the U.S. Cornbelt where corn silage makes up a large proportion of dairy cattle diets. In earlier studies, Ohio dairy scientist Rejean Bouchard found that the optimum level of sulfur in the complete diet for high-producing cows is 0.17 to 0.18%.

Because dairymen have a choice of the type of supplemental sulfur, Bouchard started short-term digestion trials to determine which type was most effective for high-producing cows.

Two different forms of sulfur are commercially marketed—one containing inorganic sulfur, the other containing organic sulfur. Bouchard tested the different forms separately and in combination.

**THE INORGANIC SULFUR** supplement was a mixture of potassium and magnesium sulfate. The organic sulfur supplement was calcium hydroxy analog of the sulfur amino acid, methionine, more commonly known as MHA.

Adding the commercial mixture of

**TURN TO PAGE 14**


# ADAM'S VISION

**RECENT ADVICE** from a university economist worked like collards before bedtime on me. I dreamed all night. Of Adam and Eve. A crazy dream.

Maybe you can explain it. But, first, you'll have to know what the economist advised:

**To survive, farmers must be prepared to live with further general price inflation and sharp crop price fluctuations completely unpredictable. To do this, hold your debt position to the very minimum—maintain a large cash reserve—and watch out for a major crop price decline in the next 2 to 4 years when we happen to hit good crop weather all around the world in the same year.**

Why on earth would such sensible, serious advice lay a collard dream on me? My fumbling, simple-minded translation probably caused it: **Hold your debt to minimum and cash reserve to maximum and wait for good weather to wipe you out—or dang near it.**

Anyway, I found myself in the first farmbelt God gave man—a place called Eden. Suddenly Adam turned to Eve, the household budget keeper:

"Honey, what do the cash reserves look like this season? W-H-A-T? You mean we STILL owe that much? Lord help us, we'll be wiped out if GOOD weather hits everywhere next season?"

Eve asked, "What can we do, Adam?"

Adam replied, "We'll make out, honey."

Then he noticed lush growth on the edge of their corn field. He strolled down while Eve fixed supper. The corn was more mature and richer looking in a small spot along the river bank—a spot where Adam and Eve liked to fish and picnic between chores.

He leaned down and poked around the soil. He remembered—the fish were so plentiful that he sometimes tossed dead ones they didn't cook into the field. He also dumped wood ashes from their picnic pit there. And worked it all into the soil to keep things clean. (Something like the system reported on Adam's heirs many years later near a seaside rock called Plymouth.)

For the first time in her life, Eve could not make Adam hear her call to a good meal. She walked down to the field. He was sitting there, as in a trance, staring into the river. Then he looked up, oblivious to her call:

"Honey, I've GOT it? See that corn? Something in those fishes and ashes made the corn do that. We'll get twice the bushels from that part of the row."

Eve was not impressed. They had so much land and so much credit at Providential Bank and Trust that she could only say, "Why do we need more corn?"

He came back to earth, "We DON'T need more corn. We need more money for the corn we have. And we can get it now."

She looked puzzled and worried. Adam had been working hard recently. He was an ambitious farmer. She couldn't hide the concern in her eyes.

She asked, "But what about the weather? You said if it came GOOD everywhere next year, we might be wiped out."

"Not now," he smiled. "Let the weather do what it likes—within reason—we'll make out. We'll get more for the corn we have."

"But how, Adam, HOW?"

He laughed and swept his arm toward the crop, "See this field? We may get the same amount of corn from half this field next year."

Eve stared at the field, then said, "And get **more money** for the **same amount** of corn. Adam, you've been working too hard. We can't beat the system."

**"Yes, we can, NOW," he almost shouted, "We'll put plenty of fish and ash on the lower half and add the money we save not working the upper half to our corn profits. I believe we've found something here, Eve. The more bushels we can get out of the land we use the less land we'll have to use. Less land means less cost. And less cost is more profit. See?"**

Eve's face brightened. The concern evaporated. And her eyes took on a Scotch glaze.

"Ohhh," she said. "Ohhhh. Well, now. Maybe we can use **half** the fish and ash you were figuring on and still . . ."

Adam broke in, "I knew it! I knew you'd figure on pinching somewhere. And wisely. **But savings that reduce yields become costs that reduce profits."**

Eve looked up at her farmer, "Why, Adam, I had no idea! You ought to sign on as an economist down at Eden State."

Adam laughed, "I just know farming, honey."

When you wake up from a dream like that, you throw out all the leftover collards and resolve to read ONLY Beetle Bailey before bedtime—and you pray "the experts" never hear about it.

# POOR SOIL TILTH

**WHEN DIAGNOSING** plants for poor soil tilth, we must be very careful because each condition may be a symptom of nutrient deficiency, dry soil, early planting, high water table, and nematodes.

**5 VISUAL SYMPTOMS:**

**In Plants . . .**

1—Slow plant emergence from the soil.
2—Shorter than normal plants.
3—Off-colored leaves.
4—Shallow root systems.
5—Malformed roots.

**In Soils . . .**

1—Soil crusts.
2—Compact zones in the subsurface.
3—Standing water.
4—Excessive erosion by water.
5—Increased power demands of tillage.

**5 COMMON CAUSES:**

1—Inadequate drainage.
2—Too much tillage.
3—Crop system without adequate residue.
4—Untimely field work—too wet, etc.
5—Poor design of farm implements.

**3 POSSIBLE REMEDIES:**

1—Water drainage, surface & subsurface.
2—No more tillage than necessary.
3—Adequate organic matter in the soil.

# Has Your Soil Had A PHYSICAL Lately . . . For Tilth?

L. S. ROBERTSON
MICHIGAN STATE UNIVERSITY

**TODAY'S INPUT COSTS** make soil tilth more vital to the farmer than ever before. ''Soil tilth'' is a term long used to relate soil structure to plant growth.

The best seed, fertilizer, pesticide, etc. cannot do their best if soil structure is not at its best. It determines how well plants grow and how efficiently crops use fertilizer.

When soil particles are so loose they dry out too rapidly or so firm they cripple root growth, crop yields suffer. Soil tilth regulates how easily water can infiltrate, air can diffuse, and roots can penetrate—and how well the land can take heavy farm machinery.

Poor soil tilth is natural in some soils, but caused by farmers in others. The condition is increasing in humid areas, especially where heavy equipment is used with intensive cropping systems that return little residue to the soil.

**VISUAL SYMPTOMS IN PLANTS include . . .**

**Slow plant emergence** from soil too cold, wet, crusty, or cloddy. Uneven stands and low populations sometimes

## DO-IT-YOURSELF FORM

Dr. Robertson has developed a simple do-it-yourself soil structure evaluation form to help determine if your soil's physical condition is having a good or bad effect on crop production and fertilizer efficiency.

For a free copy, write Dr. L. S. Robertson, Department of Crop and Soil Sciences, Michigan State University, East Lansing, Michigan 48823.

# 3 SYMPTOMS OF POOR SOIL TILTH

**PACKED SOIL CRIPPLES ROOT GROWTH,** as this experience shows. All 4 navy bean plants were growing in the same field which was worked when the soil was too wet. Why the difference? The two plants on right had the tough luck of growing in the wheel mark made by the tractor during preplant discing. This caused two classic symptoms of poor soil tilth: Shallow roots and shorter than normal plants.

**PONDED WATER** often indicates bad soil structure. A soil with good structure will rarely pond up water. This field of beans was severely damaged. Sometimes a bad crust can follow. This can be a real menace to all inputs.

**THICK CRUST** says water stood. Summer fallowing on fine textured soil destroyed natural structure of subsurface soil so water could not penetrate soil rapidly. Thicker crust is in depressions made by cultivator teeth.

# 2 KEY CAUSES . . .

**POOR DRAINAGE** can cause slabs like this because the soil is worked wet. Then, when soil dries rapidly, it's hard to get a good seedbed. Many farmers can't wait for soil to dry in spring. So, good drainage is vital.

**CLODS TURNED UP** right along the tire marks of equipment used to spread manure on wet soil. Field work cannot be timed like a city factory. But deeper plowing would loosen this compacted zone and help soil tilth.

occur even where plenty of high quality seed were used. Disease organisms—such as root rots in beans, phytophthora root rot in alfalfa, and black root in sugar beets—can strike in wet soil.

**Shorter than normal plants** from slow emergence and growth. Short plants come in cloddy seedbed produced by plowing wet soil. Such conditions are most common on fine textured soils.

**Off-colored leaves** from restricted root growth. The leaves reflect nutrient hunger or disease. Denitrification occurs in waterlogged soils. More fertilizer may reduce problem but yields are still limited. The best solution is good structure (tilth) so excessive water can drain out of root zone.

**Shallow root systems** from poor penetration. Most crop roots go deeper than 2 feet, sometimes 4 feet on long season crops, when soil structure is good. Roots should grow through soil particles, not around them—diagonally downward, not laterally. They should explore the plow layer AND the subsoil uniformly, not just the plow layer alone.

**Malformed roots** from several problems. Poor tilth can lead to "sprangly roots" and "dog legs" in sugar beets . . . to shallow fibrous roots in beans . . . . to root lodging in corn . . . and to root rots in many crops.

**VISUAL SYMPTOMS IN SOILS include . . .**

**Soil crusts.** Waterlogged soil pores lead to crusts, often on silt and clay soils, sometimes on sandy soils. Dried crusts are strong enough to limit plant emergence.

**Subsurface compact zones.** You have to dig to find this. Without crop roots to help pinpoint it, only the most extreme condition can be correctly interpreted.

**Standing water.** Soil crusts or deep compact zones can reduce fertilizer efficiency, growth rates, and crop yields. In very early planted fields of oats, barley, sugar beets, and corn, for example, heavy wheels are compacting more and more soil.

**Excessive erosion by water.** Crusts or compacted zones won't let rain or irrigation water enter the soil fast enough.

**Extra tillage power.** Some soil conditions demand big equipment to break it up. Many farmers don't recognize this symptom yet. It may become a problem as more farms use heavier tractors.

**CAUSES & REMEDIES include . . .**

**Poor drainage** in surface and subsurface causes many soils to become plastic when too wet. Machinery can then compress them badly, crushing granules, reducing pore space for water and air. This is a big problem with short growing seasons. The farmer must plant on wet soils sometimes—and harvest root crops before the soil freezes, grain crops before the snow flies.

Maintain ditches to move snow, rain, and irrigation water. Keep tile drains repaired. Smooth fields to prevent water ponding. Till to prevent low areas and provide outlets for dead furrows or use sod waterways.

**Excessive tillage** creates very small, less stable soil aggregates. Such small particles decompose, form crusts, blow and wash away much more readily than larger particles.

Till just enough for rapid germination, good stand, and rapid plant growth. Don't till wet soil. Vary plow depth by seasons to avoid tillage pans that can form under "the same depth operation." But plow no deeper than necessary to loosen compact zones.

# 2 KEY REMEDIES . . .

**TILL JUST ENOUGH** for rapid seed germination, good stand, and rapid plant growth. This farmer loosens deep lying compact zone with large chisel plow. Such large tractors and deep tillage are best when soil is very dry.

**ORGANIC MATTER** is vital to soil tilth. We must maintain and improve organic matter levels if we expect to survive. There is nothing better than alfalfa-grass mixture to stabilize the structure of our soil.

Chisel in fall when soil may be drier. Combine operations for fewer field trips. For high rates, broadcast fertilizer and lime before plowing. Pull well adjusted plow with tractor wheels on land rather than in furrow. And, when possible, favor large flotation tires for less compaction.

**Intensive cropping systems** produce too little crop residues. They demand heavier tillage, which opens the soil for air to dry out soil, but they do not return much to the organic bank account.

Many farmers no longer use cover crops or produce hay and livestock manure. Some don't even grow corn which produces good residue. Others bale and sell their small grain straw. And certain crops, such as beans and sugar beets, produce small residues, anyway.

We can maintain and improve organic matter. Begin with crop residues—then use green manure and cover crops where possible to stop accelerated soil erosion by wind and water.

Use livestock manure as a soil amendment. Include in the rotation at least one crop which produces large amounts of crop residues. Corn is fine. Control insects, diseases, and weeds for best grain and residue yields.

The best prescription for poor soil tilth is a deep-rooted legume mixed with a grass for two or more years. The grass stabilizes the structure of the topsoil. The deep-rooted legume improves the structure of the subsoil.

And to do their job right, these residue-building, structure-improving crops must be well fertilized. The beneficiary is the human race. For without good soil tilth, our species could disappear in an alarmingly short time. **The End**



## FROM PAGE 8—SULFUR

potassium and magnesium sulfate (inorganic sulfur) to a cow's diet increased dry matter digestibility, sulfur retention, and apparent sulfur digestibility, says Bouchard.

The MHA (organic sulfur) did not affect dry matter intake or digestiblity, milk production, or sulfur and nitrogen balances.

Feeding and combination of the inorganic and organic forms (by substituting calcium-MHA for part of the potassium-magnesium sulfate) decreased dry matter intake from 42.7 pounds to 38.7 pounds per day and increased fat level in the milk from 3.4 to 3.7%.

Thus, the inorganic sulfur appears to be the most effective form. However, Bouchard points out that the long-term effect of decreased dry matter intake is not currently known and is under investigation at several research institutions. **The End**


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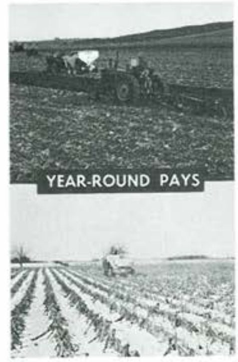


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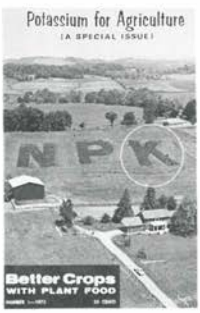


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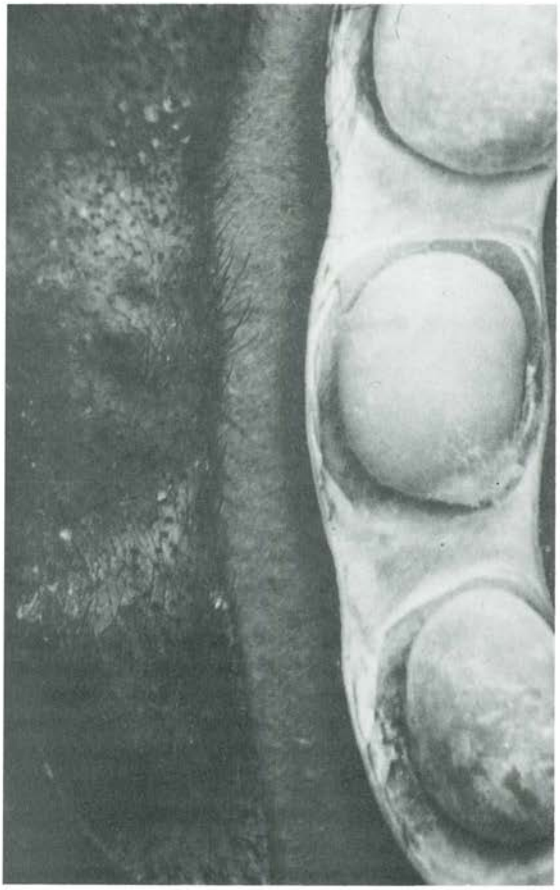


**FUNGUS CAUSING gray-moldy beans and pods like this showed up less when the crop got enough potassium.**

# Potassium Helps Soybeans Resist DISEASE

L. V. SVEC
AND
H. W. CRITTENDEN
UNIVERSITY OF DELAWARE

**GRAY-MOLDY SOYBEAN SEED,** an annual concern in Delaware caused by fungus, may be reduced by high potassium fertilization. The 1972 experiment typified all experiments in this project.

Soybean plants were grown in Evesboro loamy sand. The soil filled aluminum-lined holes were 37 cm diameter and 50 cm deep. Various rates of potassium chloride and potassium sulfate were broadcast and worked into the top 20 cm of soil in early April, 1972.

On May 18, we planted Delmar and Wayne seed and three weeks later thinned the plants to 4 per cylinder. When the plants began to flower, those originally fertilized with 30 gm/cylinder were sidedressed with 10 grams more potassium salt.

**Table 1** shows the percentage of diseased seed declining sharply as potassium level increases, regardless of potassium source or soybean variety. The highest potassium fertilization, greatly exceeding normal usage, led to a marked decrease in diseased seed—but so did the 10 grams per cylinder treatment (equivalent to either 462 or 518 lbs/A).

The varieties responded differently in yield. Delmar seemed to yield higher **(Table 2)**, largely because of producing more seeds per plant **(Table 3)**.

In **Table 4**, soil samples collected after seed harvest showed little accumulation of potassium in the cylinders, even at high potassium applications.

The very high incidence of gray-moldy seed in the plants receiving no potassium was quite typical of some

**Table 1**—The Percentage of Gray-Moldy Seed Decreases As Potassium Fertilizer Increases.

| Potassium Chloride (KC1) or Potassium Sulfate ($K_2SO_4$) added per cylinder | POTASSIUM APPLIED As KC1 | POTASSIUM APPLIED As $K_2SO_4$ | DISEASED SEED Delmar | DISEASED SEED Wayne | AVERAGE |
|---|---|---|---|---|---|
| 0 grams | 0 lb/A | 0 lb/A | 87% | 62% | 75% |
| 2 | 92 | 70 | 65 | 58 | 62 (LSD $_{.05}$ = 6.0) |
| 10 | 462 | 518 | 21 | 33 | 27 |
| 30 + 10 sidedressed | 1850 | 2074 | 13 | 14 | 13 |
| | | Average | 46 | 42 | 44 |
| | | (LSD $_{.05}$ = 4.3) | | | |

**TABLE 2**—How Potassium Fertilization Affected The Weight of Seed Per Plant

| KCl or $K_2SO_4$ Cylinder, grams | Yield, grams/plant Delmar | Yield, grams/plant Wayne | Average |
|---|---|---|---|
| 0 | 33.5 | 28.2 | 30.9 |
| 2 | 36.6 | 27.7 | 32.2 (LSD $_{.05}$ = 4.5) |
| 10 | 38.6 | 28.9 | 33.7 |
| 30 + 10 sidedress | 36.7 | 28.2 | 34.5 |
| Average | 36.4 | 28.3 | 32.3 |
| (LSD $_{.05}$ = 3.18) | | | |

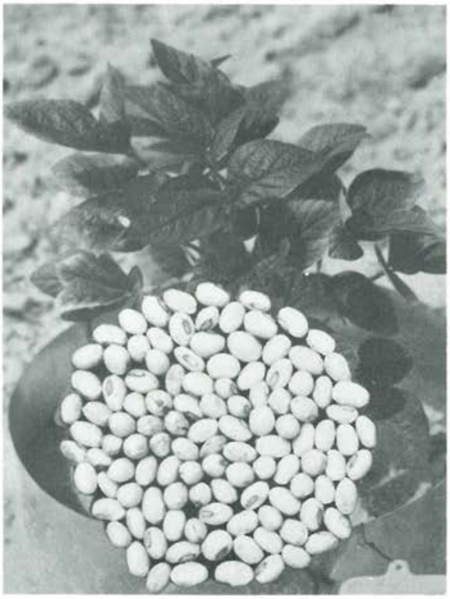
**TABLE 3**—How Potassium Fertilization Affected The Number of Seeds Per Plant.

| KCl or $K_2SO_4$ per cylinder, grams | Number of Seeds per Plant Delmar | Number of Seeds per Plant Wayne | Average |
|---|---|---|---|
| 0 | 254 | 200 | 227 |
| 2 | 262 | 207 | 235 (LSD $_{.05}$ = 30.1) |
| 10 | 275 | 209 | 242 |
| 30 + 10 side-dress | 264 | 200 | 232 |
| Average | 263 | 204 | |
| (LSD $_{.05}$ = 21.3) | | | |

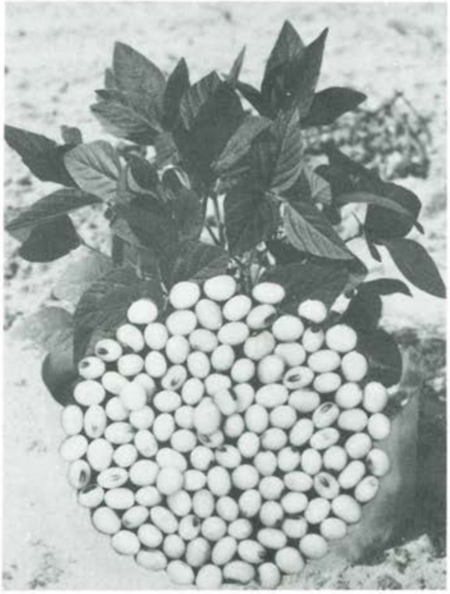
**TABLE 4**—Soil Test Results From Soil Cylinders Fertilized With Potassium Fertilizers For Soybean Growth.*

| Amount and Type of fertilizer per cylinder | Nutrient Measured in Soil Test, lbs/acre K | P | Mg | pH |
|---|---|---|---|---|
| 0 (Check) | 68 | 128 | 186 | 6.6 |
| 2 g KCl | 97 | 154 | 201 | 7.0 |
| 2 g $K_2SO_4$ | 63 | 134 | 165 | 6.9 |
| 10 g KCl | 116 | 127 | 176 | 7.0 |
| 10 g $K_2SO_4$ | 92 | 113 | 134 | 6.8 |
| 30 g KCl + 10 g KCl side-dress | 114 | 127 | 139 | 6.8 |
| 30 g $K_2SO_4$+ 10 g $K_2SO_4$ side-dress | 133 | 158 | 151 | 6.7 |

* Soil samples collected after seed harvest completed.



WITH NO ADDED K, yellowing leaves and gray-moldy beans said nutrition was out of balance for strong resistance.



WITH ADDED K, healthy leaves and beans said potassium had brought nutrition into balance for strong resistance.

soybean varieties grown on Evesboro loamy sand not heavily fertilized. This particular soil had not received fertilizer for 3 years before this experiment.

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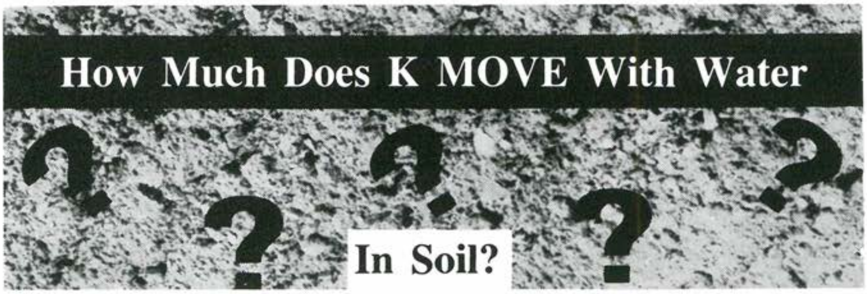
For the past 4 years, studies comparing these and other varieties have shown similar results—as potassium fertilization increases, the percentage of gray-moldy seed decreases.

Potassium levels applied in these experiments far exceeded normal potassium usage. But sharp decrease in diseased seed may be a worthwhile result of high potassium fertilization, and the decrease in disease at levels of 400-500 pounds/acre indicate adequate potassium is important.

Using resistant varieties with good fertility practices should produce a high quality, high yielding soybean crop.

Further studies of soybean pod and seed physiology and response to potassium fertilization are needed to better understand why varieties differ in disease susceptibility and the role potassium plays in fungus diseases.

**The End.**



# How Much Does K MOVE With Water In Soil?

A. C. CALDWELL, A. CASTRO, L. GOODROAD
UNIVERSITY OF MINNESOTA

**POTASSIUM MOVES** very little in a soil, even in loamy sand receiving heavy water supplies.

When we investigated the movement of nitrates, sulfates, and chlorides into an aquifer under irrigation, we applied 415 lbs K/A to the soil surface at the beginning.

Most of this K—over 86%—was still in the top 2 feet of loamy soil after receiving 46 inches of water in 55 days. **Table 1** shows nearly all the added K accounted for (800-430=370 lb K/A) and no evidence of K moving into the aquifer.

The aquifer waters tested 2.6 ppm K after 2 days, 2.2 ppm K after 31 days, and 2.2 ppm K after 50 days of watering.

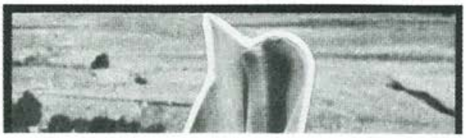
At the same time, these waters tested 56 ppm Ca after 2 days, 131 ppm Ca after 31 days, and 214 ppm Ca after 50 days of watering. So, there was some cation movement.

The thin alfalfa stand on the area took up a small, but determined amount of K. The alfalfa was clipped occasionally, but not removed.

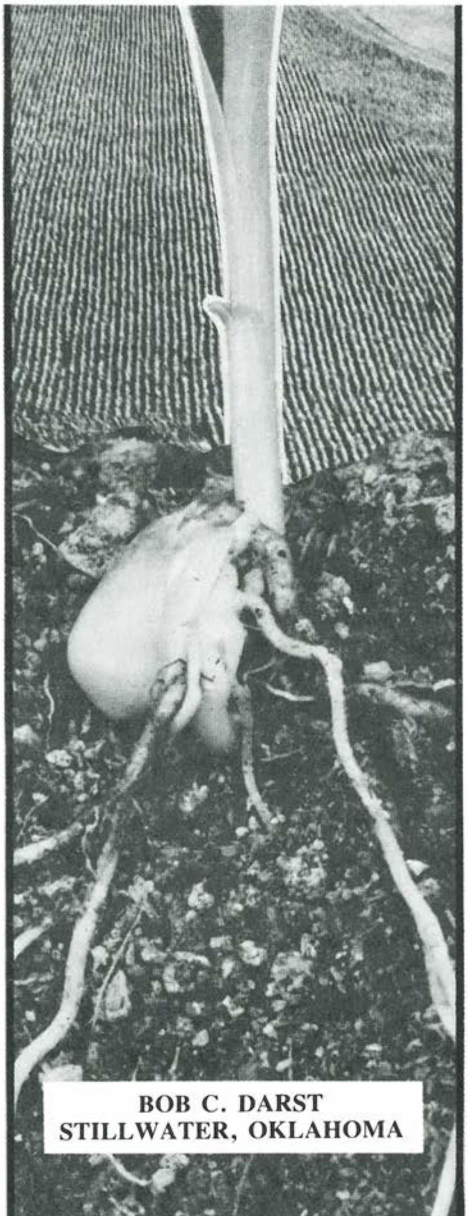
It has been said K moves in sandy soils. These tests proved it moves relatively little—on a soil containing 80% sand, 10% silt and 10% clay, 1.5% organic matter, 6.5 CEC, 6.2 pH **in the surface foot** and 85% sand, 6% silt and 10% clay, 4.25 CEC, and 6.6 pH **in the second foot. The end.**

**TABLE 1**—K Content of Soil Before and After Application of 415 lbs K/A and Irrigation with 46″ of water

| Soil Depth feet | K Content of Soil (lbs/A): Before Application of K and Water | 55 Days After Application of K and Water |
|---|---|---|
| 0-1 | 160 | 440 |
| 1-2 | 80 | 160 |
| 2-3 | 40 | 40 |
| 3-4 | 30 | 20 |
| 4-5 | 20 | 30 |
| 5-6 | 20 | 20 |
| 6-7 | 20 | 20 |
| 7-8 | 20 | 30 |
| 8-9 | 20 | 20 |
| 9-10 | 20 | 20 |
| Extractable K to 10 feet | 430 | 800 |



# Fertilizer Helps The Plant Use Water More EFFICIENTLY



BOB C. DARST
STILLWATER, OKLAHOMA

**2nd IN STRESS SERIES**

**IF OUR FOOD SUPPLY** depended on plant roots "growing" to the nutrients that feed them, we would be in bad shape.

To some extent, roots can "grow" to plant nutrients—but they don't get enough nutrition this way to support the plant.

The roots must depend on moisture to move most of the nutrients through the soil to them. This movement occurs through two processes—**mass flow** and **diffusion.**

Crop yields depend on that important relation between soil moisture and nutrients. Too little or too much moisture can create critical stress in the crop and undermine badly needed yields.

When the soil is too dry, plant growth declines because water and nutrients are in short supply. There's not enough moisture to MOVE the nutrients to the roots for best yield.

When the soil is too wet, soil pores become clogged with water. This shuts off oxygen supplies to plant roots. Without adequate oxygen, the plant can't breathe enough to get the energy to absorb nutrients. Normal growth declines or stops.

Although most moisture stress problems are caused by too little water, experience and research show too much water can be just as damaging.

For example, flood waters can coat, bruise, and scald plants. Poor drainage can restrict plant growth and nutrient uptake and sometimes cause plants to take up toxic amounts of manganese and iron. Excessive water can cause nitrogen loss through denitrification. And cold, wet soils can slow early growth so vital to final yield.

**ADEQUATE FERTILITY** is like an insurance policy in soils too dry or too wet. It puts more nutrients in the

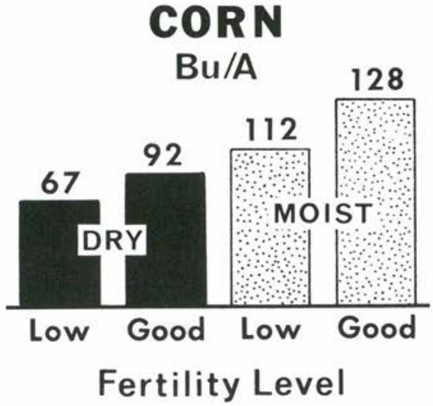



**FIGURE 1—Good fertility on limed soil adds bushels to corn under stress.**

direct vicinity of the plant roots where crops can respond under stress.

And crops DO respond. How much depends on the amount of stress. Additional potash boosted this Indiana corn yield dramatically. Why? Because only 6 to 10% of the total potassium required by plants was in direct vicinity of the

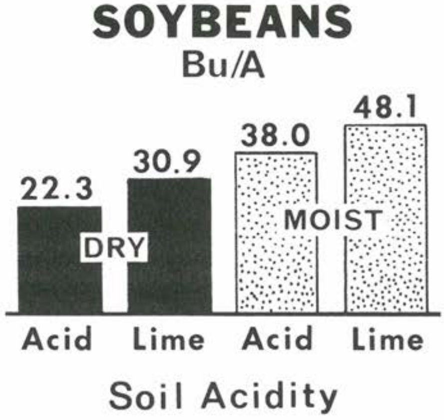



**FIGURE 2—Lime with good fertility adds bushels to soybeans under stress.**

# STRESSURANCE

**WE CAN buy life and accident insurance—but no yield insurance. Yet, there is a policy called stressurance. It helps crops get through stress periods. It is underwritten by adequate fertility. It's a good policy. There's plenty of evidence around:**

- **In Arizona, additonal fertilizer on alfalfa increased irrigation efficiency 34%—nearly 3 tons more hay per acre with 4 inches less water per ton.**

- **In Colorado, additional fertilizer produced 51% more bushels of corn per inch of water.**

- **In Illinois and Iowa, fertilized corn reached between 5 and 7 feet deep for its moisture, unfertilized corn only 3 or 4 feet deep.**

- **In Missouri, fertilized corn used 15,400 LESS gallons of water to produce 61 MORE bushels per acre.**

- **In Alabama, cotton seedlings showed little root penetration into subsoil that remained strongly acid—but seemed to take off for deeper moisture when lime was in the subsoil.**

■ **The deficiency of just one nutrient seems to increase a crop's thirst. As the nutrient runs low, plant growth slows down drastically but its transpiration (moisture exhale) does not slow down much. So, it uses more water to produce less crop.**

plant roots before the additional potash was applied.

| RAIN (IN.) | CORN Bu/A No K | K | Bu/A Increase |
|---|---|---|---|
| 7.91—Dry | 91 | **130** | 39 |
| 17.68—Normal | 148 | **156** | 8 |
| 25.73—Wet | 92 | **140** | 48 |

High fertility cannot completely remove moisture stress, of course. But it can help offset bad effects. **Figures 1** and **2** show how good fertility and liming helped corn and soybeans through dry and wet periods.

When soil moisture runs short, the need for high potassium and other nutrients in the soil becomes critical. Why? Because the less moisture there is the less diffusion channels there are in the soil for moving nutrients to the plant roots. Low moisture shortens diffusion channels.

Only two things can help this crisis—more moisture to move the available nutrients to the root system or more nutrients available in the root vicinity.

The higher the exchangeable K level, for example, the greater the diffusion through the soil. One thing is certain—when the soil does not have enough exchangeable K to replenish what the crops remove, the best mass flow and diffusion rates will not get enough nutrition to those roots.

**SPLIT ROOT TECHNIQUE** grows part of the root system under "normal" conditions and part in a controlled environment to test certain factors.

Such studies have revealed interesting relations among soil moisture, nutrient availability, and root hospitality:

**1**—Both high and low moisture conditions reduced K availability to the plant root.

**2**—Optimum moisture conditions (neither too high nor too low) made K more available to corn roots and caused dry weight yields and P-K-Mg percent in plant tissue to increase on line with increasing moisture up to optimum soil content.

**3**—Tomatoes grown under moisture stress accumulated much less N and P in young plants and showed lower RNA synthesis rate in leaves.

**4**—A plant struggling through extreme water content did not use the P that diffused toward its root surface—indicating stress conditions can inhibit physiological processes in the root.

**IT HAS BEEN SAID** that fertilizer stretches moisture. That may be right. In one study, very high K rates were used to grow sugar beets—high enough to inhibit normal growth, they thought. Instead of inhibited growth, they got greater yields of beets with higher sugar content from less moisture.

In another study (57 experiments on 3 major crops in Nebraska), nitrogen increased corn yields 42 bushels per acre with 44% better water use . . . wheat 6 bushels with 12% better water use . . . and oats 20 bushels with 38% better water use.

When 150 lbs N per acre was applied to irrigated corn in Colorado, yields increased 56 bushels per acre. Each inch of water produced 4.9 bushels *without N*, 7.4 bushels *with N*. Fertilizer increased water use efficiency 51%.

When Georgia researchers used good fertility with adequate growth between clippings, they got 7 times more Coastal bermudagrass per acre inch of irrigation water applied. This table shows very efficient use of water:

| CLIPPING | Fertilizer N | Lbs/A K | Grass:Water Tons/A Inch |
|---|---|---|---|
| 2 weeks | 200 | 100 | 0.10 |
| 6 weeks | 1,000 | 500 | 0.72 |

**THE SOIL TYPE** affects the amount of stress limited moisture will put on a growing crop. In one study, moisture stress influenced P diffusion rates much less in clay soils than in lighter-textured soils. Researchers concluded that added P must be increased as water content decreases in order to maintain a given diffusion rate in a soil.

An Oklahoma study showed similar effects on winter wheat. Moisture stress, high temperature, and coarse-textured soils joined hands to reduce emergence.

Moisture stress can delay corn silking. The delay may or may not reduce fertilization of the ears but usually lowers yields. Grain sorghum research shows stress before heading and flowering reduces yields less than stress after head emergence.

Texas researchers have created a mathematical system for predicting how efficiently dryland grain sorghum will use nitrogen during moisture stress. The system uses available soil water levels, previous weather records and crop yields to calculate the crop's response to N fertilizer.

The system has shown the crop's response to N decreases as the number of stress days increases. The following table shows the relationship between N application and moisture, using continuous dryland grain sorghum as the test crop. Yields are in pounds per acre:

| STRESS | Lbs N/A | |
|---|---|---|
| DAYS | 0 | 100 |
| 0 | 2675 | 4748 |
| 10 | 2671 | 4358 |
| 20 | 2668 | 3968 |
| 30 | 2664 | 3579 |
| 40 | 2661 | 3189 |

Most profitable N rates will depend on many factors, including relative price of grain sorghum and N fertilizer.

**WHEN APPLYING ENOUGH** fertilizer to overcome moisture stress, do we risk great loss from downward movement through the soil? Not according to Minnesota tests with potassium.

During a year when high K rates were surface-applied to alfalfa on a sandy loam, rainfall was the highest since 1916. But most of the K remained in the surface soil where it was applied. This table tells the story:

| DEPTH (Inches) | EXCHANGEABLE K LBS/A |
|---|---|
| 0— 2 | 600+ |
| 2— 3 | 410 |
| 3— 4 | 180 |
| 4— 5 | 90 |
| 5— 6 | 70 |
| 9—10 | 45 |

We cannot control weather. But we **CAN** control fertility enough to help the crop through bad weather stress with respectable yields, many times. One of the best times to apply phosphate and potash is in the fall, right behind harvest, to "stressure" the soil against next year's dry or wet spells. **The End**

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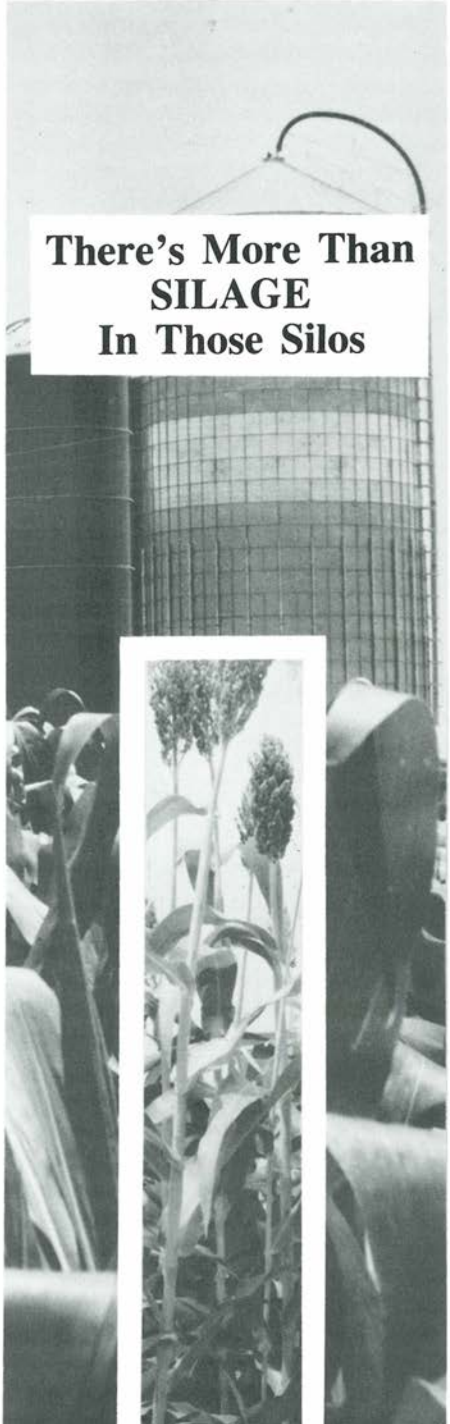
# There's More Than SILAGE In Those Silos



H. A. FRIBOURG, W. E. BRYAN,

**WHEN WE TESTED** the amount of nutrients corn and grain sorghum silage took up in 34 experiments, more than half the harvests contained larger amounts of nitrogen and potassium than had been applied in fertilizer.

This means the crops were not only using all the nitrogen and potash fertilizer they were receiving, but also were tapping the soil sources.

This also means those great silos many admire across the lush fields from the expressway contain large quantities of nutrients in the chopped-up leaves and stalks.

Even those of us working to keep America well fed don't often see those silos as huge warehouses of nutrients extracted from the soil by the crops they are curing.

But, in a sense, that's what silos are—huge nutrient storehouses. Silage crops are greedy nutrient grabbers—greedier than grain alone, because they take away more of the crop.

**WE EXAMINED** this greed in 34 experiments on 12 soils at 6 locations, adding irrigated plots to 5 of the soils. We harvested the corn for silage when 80 to 90% of the kernels were dented, the grain sorghum when oldest seeds were in the soft dough stage. We tested tissue samples for total seasonal uptake of N, P, K, Ca, and Mg. And we adjusted plant populations to average 18,000 corn plants and 22,500 sorghum plants per acre.

The silage yields of dry matter (multiply by 3 to get weight put in silo) varied widely, according to planting dates and climate differences. Corn ranged between 6 and 18 metric tons/ha (2.7-8.0 t/acre) with three sites giving between 21 and 28 metric tons/ha (9.4-12.5 t/A). Grain sorghum ranged between 7 and 18 metric tons/ha (3.1-8.0

t/A). The same yield range was sampled with both crops on all but three sites.

**THE BEST YIELDS** came from a combination of early planting, soils that can hold much available moisture, and irrigation in some cases. Yields were depressed about the same by inadequate moisture for both crops.

**Table 1** shows all yield classes, from lowest to highest, taking up more and more nutrients as yields increased. Grain sorghum tended to take up more nutrients than corn at the lower yield levels.

The applied NPK—142 kg N, 48 kg P, and 98 kg K/ha (127 N, 43 P, and 87 K lb/acre)—did not limit silage production, though good management might demand higher potash rates than these tests received. Most of the harvested silage contained less P, but more N and K, than we added in the NPK fertilizer.

The modern farmer may be more conscious of nutrient uptake than he has ever been. Such tests help him increase his knowledge in this important aspect of farming. **The End**

**TABLE 1**—Average nutrient uptake increased as yields of corn and grain sorghum silage increased in 34 experiments during 1969.

| SILAGE CROP | EXPERIMENTS | Dry Matter Yield | | Average Nutrient Uptake | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Classes | Avg. | N | P | K | Ca | Mg |
| | Number | t/ha | | kg/ha | | | | |
| CORN | 5 | 6.0- 8.9 | 7.52 | 111 | 14.8 | 78 | 19 | 25 |
| | 5 | 9.0-10.9 | 9.62 | 160 | 19.1 | 107 | 26 | 26 |
| | 4 | 11.0-12.9 | 11.81 | 173 | 23.4 | 140 | 37 | 31 |
| | 8 | 13.0-14.9 | 13.89 | 182 | 27.3 | 151 | 37 | 37 |
| | 6 | 15.0-15.9 | 15.57 | 202 | 32.4 | 167 | 46 | 45 |
| | 3 | 16.0-18.9 | 17.17 | 246 | 41.2 | 173 | 53 | 45 |
| | 3 | 21.0-28.9 | 24.43 | 361 | 51.4 | 224 | 73 | 62 |
| | Avg. | | | 192 | 28.0 | 144 | 39 | 37 |
| GRAIN SORGHUM | 5 | 7.0- 9.9 | 8.82 | 137 | 18.2 | 100 | 28 | 28 |
| | 8 | 10.0-11.9 | 10.88 | 159 | 20.8 | 128 | 31 | 30 |
| | 10 | 12.0-12.9 | 12.46 | 173 | 26.6 | 139 | 39 | 34 |
| | 7 | 13.0-14.9 | 14.03 | 171 | 28.7 | 159 | 49 | 39 |
| | 4 | 15.0-17.9 | 15.92 | 213 | 40.8 | 212 | 57 | 48 |
| | Avg. | | | 169 | 26.1 | 143 | 40 | 35 |

To convert T/ha to T/A multiply by 0.446.
To convert kg/ha to lb/A multiply by 0.892.

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