BETTER CROPS with plant food

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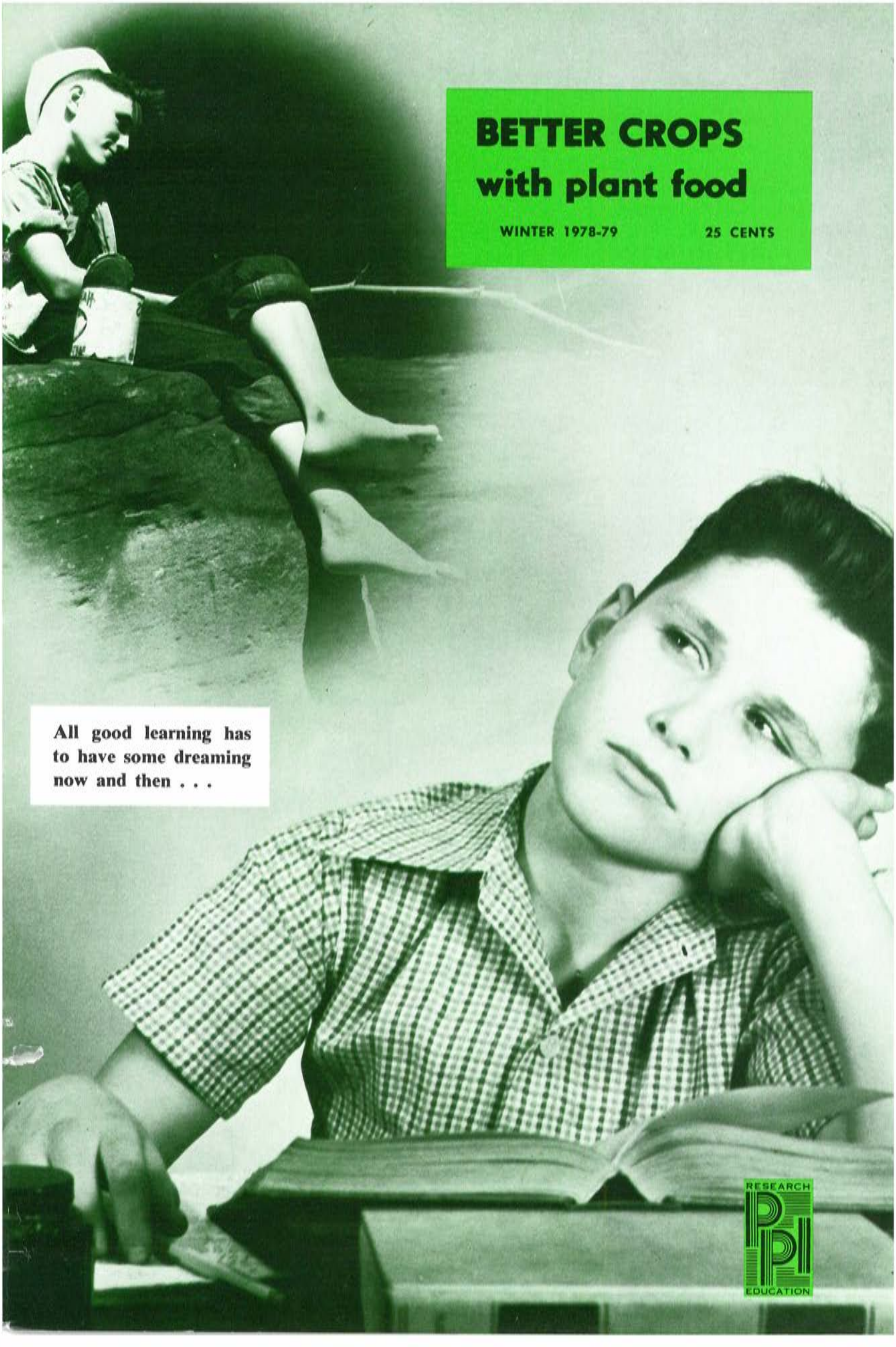

All good learning has to have some dreaming now and then . . .

BETTER CROPS with plant food

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Contents

Agricultural Science Foundation For World Peace — 3
Earl Butz

Four Keys To 5-8 Tons Alfalfa — 8
M. B. Tesar

Foods Instead of Drugs To Offset Potassium Losses In Diet — 14
Bill Agerton

200+ Bushels Per Acre Corn Yields in the U.S. — 16
David Dibb and W. M. Walker

Beating The Odds with High Corn Yields — 20
William Walker

Potassium Deficiencies In Northeast Saskatchewan — 22
Roy Button

Seeding Orchardgrass Into Alfalfa Successfully — 24
C. L. Rhykerd, R. O. Blair, and N. P. Maxon

Soybeans Need Phosphorus For Adequate Nodulation — 26
R. G. Hanson

Nitrate Accumulation In Corn And Nitrate In Animals — 28
C. H. Noller and C. L. Rhykerd

Bifocals — 30

AGRICULTURAL SCIENCE
Foundation For World Peace

EARL BUTZ
Dean of Agriculture Emeritus
Purdue University

MUCH OF THE WORLD'S turmoil can be traced to man's quest for food, and the quest for land on which to grow that food.

It's been said you can reconstruct any nation's history, its ups and downs, by following its attempts at land reform, or its bickering over how to divide the spoils of the earth.

Increasing food production during the next 25 years will be man's greatest test. Potential food shortages within a quarter-century could serve as the catalyst for man's final act of self-destruction.

The way in which we view agricultural production today, the priorities the world places on food, will hold the answers.

I, for one, believe the human race will solve its food production problems and hopefully stabilize its population in the remaining few decades left to do so. But, these are high hopes which can come only with wisdom and action, not folly and talk.

Even from the beginning, food has held the key in man's earthly story. Eve ate the apple. Adam became a farmer.

Our oldest histories tell us of the struggle between the nomadic peoples who grazed livestock, and the sedentary tribes who raised crops.

THE STRUGGLE over grazing rights provided us with the great legends of our own West: The battles between ranchers and sheepherders; the wars between cattlemen and homesteaders.

Even before that, most of the trouble among the North American Indians came when one tribe encroached upon another's hunting grounds.

Colonial empires were often built on the basis of gaining raw materials, usually food, for the Motherland. America itself was discovered in the search for shorter trade routes to the Far Eastern land of spices and tea.

In our development days, many of the European loans which helped build this country were paid off with shipments of grains and tobacco.

When Hitler began his drive which touched off World War II, his cry was "Lebensraum"—living space, productive land.

A quarter century ago the foundations of today's European Community were laid as a noble effort to "debalkanize" Europe. But, in practice, the chief thing that holds it together today is its Common Agricultural Policy.

National and international politics often center on food. The United States itself has supplied $25 billion of food aid to other countries in the last two decades—mainly for humanitarian purposes, but sometimes also to help bring political stability.

THE WORLD FOOD CONFERENCE in Rome two years ago was called to deal with impending food shortages. When the discussions began, most of the representatives turned their interests to short-term emergency food distribution, rather than planning for increased food production in the future.

But, in concentrating on emergency distribution and plans for future reserves, the point was missed that, unless production is increased, there would soon be little emergency food to distribute.

In summary, food is perhaps the most potentially explosive factor in the internal politics of over half of the nations of the world today.

We are now face-to-face with the fact that the world's Number One Problem is how to feed 80 percent more people in the next quarter-century.

Or, put another way, "Allow for slight improvement in individual diets and the job becomes one of learning in the next 25 years how to feed as many more people as we've learned to feed since the dawn of history."

This is a frightening prospect. It is one to which the world must address itself seriously—and quickly.

We must find the answers at a time when there is no new Western Hemisphere to discover, no new prairie sods to plow, no more virgin woods in temperate climates to clear and convert into farmland.

WE MUST DOUBLE FOOD production at a time when most nations are losing arable land to urban sprawl, highway construction, and recreation.

Demographers predict that in 30 years, earth's human population will be 6.5 to 7.0 billion, compared with 4.0 billion today.

Can we feed those 7 billion people 30 years from now?

The answer is simple. Yes, we can—or they won't be here.

The question is not can we feed them, but can we feed them well. For that half of the world's population that goes to bed hungry most nights, can we make eating an exciting experience? Can we make eating something more than a mere exercise in sustaining a spark of life inside an emaciated body?

CAN WE PRODUCE and distribute enough food to generate the sort of happiness and satisfaction that will promote international political tranquility?

The answer to all these questions is a resounding yes:

- **If we continue to incorporate the latest and best technological advances into our agriculture.**
- **If we continue with a program of intensive and far-reaching agricultural research.**
- **If we continue to develop new sources of fertilizers and use them wisely.**
- **If we continue to develop new types of pesticides and use them wisely.**
- **If we maintain a viable system of credit to provide the massive capitalization required for intensive agricultural production.**
- **If we continue to hold together a system of individual freedom and incentives that reach each and every farmer willing to strive for them.**

The above qualification applies mainly to agriculture in the developed world. But, many other countries will need these things and more—if they are to develop into viable agricultural producers, capable of sustaining their own populations.

The United States alone cannot feed the world—no matter how productive we are. It's possible to expand our farm production by a goodly degree, but not enough to serve the explosive food needs of all the world.

Already, we are carrying a sizable portion of the load. In recent years, we have exported approximately 100 million tons of grain (including soybeans and rice) to other countries.

We supply about 55 percent of all the feed grains that move in world trade, 50 percent of the wheat, and about 70 percent of the soybeans.

Even if we could double our contribution to world food trade in the next 25 years, we could not take up the slack.

AGRICULTURAL PRODUCTION must be increased in the indigenous areas where it will be consumed.

The main avenues for agricultural gains are: (1) continued emphasis on research and development, and application of new techniques and farming techniques; and (2) the strengthening and extension of incentive systems for the man on the land.

The first will not be too difficult. Modern technology is transferable. Research results can cross oceans and mountains overnight. Scientific developments that have taken 20 years to perfect can be transported to other countries in months.

But strengthening incentive systems for the farmer is far more difficult. Yet, it is just as crucial. Too often, we have believed the road to more food for the developing countries is paved only with technology and science. Yet, those techniques, when transplanted, have sometimes withered on the vine, almost before our own technicians could get out of the field.

Why?

Was it because the local farmer was illiterate? Was it simply because he was hung up with old ways and didn't want to change?

NO! It was often because there was no real incentive for him to take the risk to change. Talk is cheap. Explanations with no cash behind them are disposable.

People have been telling the developing nation farmer for years how much better he should do things—but too infrequently have they created an economic environment with good prospects for increasing his real income?

Too few national governments have made the commitment to assure that changes in techniques would provide real incentives to the individual.

IF A DEVELOPING nation farmer can see how a change will bring a profit, he'll change in a hurry.

Farmers in India and Pakistan who had a chance to profit by planting the new varieties of wheat switched faster than our own farmers first accepted hybrid corn.

Farmers in the Philippines made the same high-speed switch to new high-yielding rice varieties once they saw the returns they could get.

Too many nations, including our own, have an underlying but powerful urge to pursue a cheap food policy—making it difficult for the man on the land to reap the reward from the innovations he makes.

Consumers the world around welcome such a cheap food policy—and politicians respond, whether they're capitalist or communist.

As nations become less agricultural and more urban, the incentive base for the farmer becomes less certain. It becomes more susceptible to political pressures and special interest dealings.

INCENTIVE IS AS important for the farmer who farms with a forked stick behind a water buffalo in India as it is to the man who rides a $35,000 tractor in Nebraska.

Yet, politicians often fail to perceive this simple fact.

Even in our own highly literate nation, we have seen repeated attacks on the incentive system for farmers.

We have had such campaigns as the beef boycott, eat one less hamburger per week, or Meatless Tuesdays. It has been only three years since political pressures forced us into a system of federally imposed price ceilings on meats and other food products.

It has been less than three years since the American Bakers Association whipped up a scare campaign that bread would go to a dollar a loaf unless we imposed export controls on wheat.

It's been less than two years since an emotional reaction to the sale of grain to the Soviets induced a suspension of sales—in spite of record harvests.

It's been less than two years since the longshoremen refused to load Gulf-port grain that was destined for Russia —on the pretext of keeping living costs under control—while they did some fancy contract maneuvering of their own. Millions of housewives applauded the action.

WHILE THE MOTIVE for each of these examples may have varied, the net result was the same.

It sent back several signals:

- **A signal to producers that we were a nation which would interfere with farmers' access to a free market.**
- **A signal that the farmer should exercise caution in making yield-increasing investments in fertilizer, chemicals, seeds, or machinery.**
- **A signal to some would-be young farmers that they are really thinking about the wrong vocation.**
- **A signal to some investors that agriculture really isn't too good a place to put their capital.**
- **A signal to some farm families that opportunities for satisfactory living might be better somewhere else, in some business where there was less danger of restraint on seeking and serving available markets.**

The sad part is that these negative signals, these arbitrary restraints, didn't happen in some distant land. Didn't happen in a dictatorial society. Didn't happen in a Communist State. Didn't happen under a government dedicated to suppression of human rights. Didn't happen under a political system based almost completely on central planning.

They happened in the United States.

They happened in the world's greatest democracy.

They happened in a nation whose hallmark is freedom of choice and freedom of action.

They happened in a nation whose level of economic literacy is perhaps the highest in the world.

They happened in a country where the legislative body reputedly reflects the will of the people better than in any other nation.

NOW, WE MUST ASK, have we learned our lesson from taking those negative acts?

Have we learned that if the United States is indeed to use its great food productive capacity, then the individual farmer must be free to produce and market his crops as he sees fit?

We must not dampen the incentives that have made our farmers the producers that they are. We must not signal to them in the language of price—the language they understand best—that we want less, not more.

We must not periodically signal to our farmers that they have only limited access to markets beyond their shores. We must not periodically throw governmental controls at them that dampen their plans for investment, their dreams of expansion, their hopes for success.

Our nation—and indeed every nation in the world—must make the commitment to move agriculture and food production to the front burner.

It must be moved higher on the scale of priorities in both national policy and in capital allocation.

Our national and international commitments to agricultural science must be strengthened.

To do less will be to condemn hundreds of millions of people to such a substandard level of living in a few years that peace will be difficult, if not impossible.

There are various estimates about the number of people who already go to bed hungry or malnourished each night. Today, in a world of instant communications and far-reaching mobility, hungry people have power. They exercise the franchise. They have the power to topple governments. They have the power to start revolutions.

HUNGRY PEOPLE WILL, in time, no longer remain invisible or silent. No matter how remote their village, they now hear of the outside world on transistor radios.

Many of them see movies. They see affluent travelers from North America, Europe and Japan. They now realize that a better life is indeed possible.

Increasingly, they will not settle for less. They see a ballet of affluence dancing all around them—and they dream of a piece of the action.

Hunger is the stuff out of which revolution is born. And, revolutions, once started, have a tendency to spread. They are like a pebble dropped into the pond. There is no way of knowing where the ripple will hit the shore.

The oceans on either side of us are no insulation. Four times in the generation of many reading this, the United States has been drawn into conflict away from our shores. There is no way we can avoid it the next time.

That is why this nation's agriculture now commands such a strategic position. Other nations may have Petro-power, but we have Agri-power—and we have it in abundance.

It is to our door that nation after nation will beat the path for food, and for the know-how to grow better food.

To the extent that we can respond to those needs, we will lay the foundations of peace.

America must help the world learn to grow food. We must use our Agri-power wisely and with strength. We must do these things not because we are a humanitarian nation, not because we are a Christian nation, not because we are a generous people—but just because we are Americans.

In the years ahead, it will be impossible for the United States to exist as an Isle of Affluence in a Sea of Human Misery. **The End**

This paper was delivered by Dr. Butz in the **Beatrice Foods Distinguished Leadership** series at the Institute of Agriculture and Natural Resources at the University of Nebraska.

WILL YOU HELP US? YOU CAN!

Do you read any of this magazine? How much?

Are the articles too long, too general?

Is the information slanted or objective, in your view?

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You can answer these questions on page 12. Then remove the page, fold it, and mail it to us at no cost to you.

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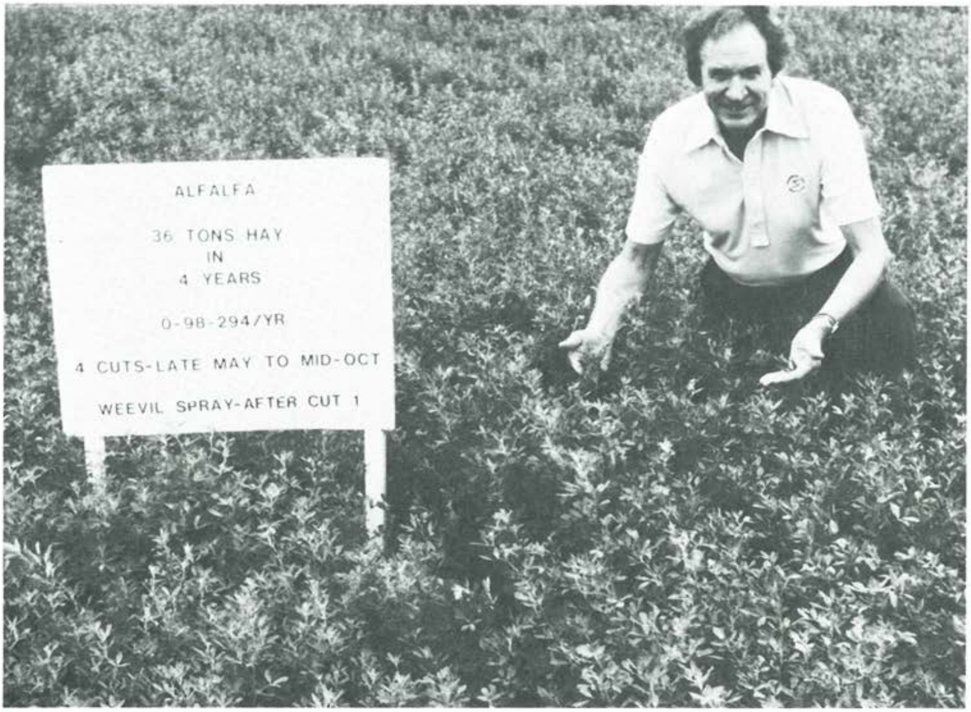


ALFALFA YIELDED 9 T/A FOR FOUR YEARS. In four years 36 tons of alfalfa hay were harvested off research plots that were fertilized with 0-98-294 every year, had four cuttings each year from late May to mid-October and were sprayed for weevil after the first cutting. This 9 ton/A/yr was produced in an area receiving an average of 30.4 inches of precipitation/yr with no irrigation.

Four Keys To 5-8 Tons Alfalfa

M. B. TESAR
Michigan State University

OVER 7 TONS HAY PER ACRE— that's what 11 out of 36 alfalfa varieties averaged during 8 years of trials at East Lansing, Michigan (1970-77). One variety yielded 64 tons of superior quality hay in 8 years—8 tons from 4 cuts each year. This was on fertile, tilled loam topdressed yearly with 0-98-294 (pH 7.2, P 8, K-132).

In another test on Conover loam, one variety produced over 9 tons (compare to 7.5 for Vernal) per year for four years. Half of 40 varieties produced over 8 tons. Topdressing was 0+98+294 per year. A 4-cut system, late May to mid-October, was used.

TOP YIELDS REQUIRE TOP MANAGEMENT. Fourth cutting (mid October) of clear-seeded alfalfa in its second year produced over seven tons hay in 1978 in mid-Michigan. Yields in the year of seeding, using Eptam herbicide instead of a companion crop, were over three tons per acre in three cuttings. Soil test levels are high—109 P and 480 K with a soil pH of 6.8. Seven hundred pounds of 0-14-42 are topdressed annually to maintain high yields and high soil test levels of 109 P and 480 K.

HOW ARE 5 TO 8-TON YIELDS PRODUCED? Get a good stand!

Choose well-drained soil with good moisture-holding capacity. Bring soil pH to 6.8 or above. Lime far ahead to insure the soil at this point at seeding. Inoculate and band seed with about 100 lbs P_20_5 and K_20/A.

Phosphorus is vital to getting seedlings off to a fast start. Use press wheels or a cultipacker after seeding. Clear seed alfalfa alone, using Eptam incorporated preplant or 24 post emergence when the alfalfa is about one inch tall.

Seed as early as possible on a well prepared seedbed to get 2½ to 3 tons alfalfa in the seeding year. If oats are needed for grain or straw, seeding in oats is good. It is used on 2 of 3 seeded acres in the North Central region.

Summer seedings on late July or early August have been very successful in Michigan and in the Corn Belt or Northeastern states except in most northerly areas. Plan for 3 cuttings and 2.5 to 3.5 tons that first year when clear seeding in a humid area.

A 3-ton crop will produce almost a half ton of protein in the seeding year.

After getting such good stand, how can you continue to get good yields?

Try four management keys:

KEY 1—THREE TO FOUR CUTTINGS. Take three cuttings instead of two in southern Michigan, the first in late May or early June (late bud stage). Second cutting when flowering starts July 5-10. Third cutting after flowering starts.

Yields climb a TON by taking the fourth cut for silage (hay under ideal conditions) in mid-October and after a third cutting about August 17-25 on the most intensively managed land in southern Michigan and similar climatic areas.

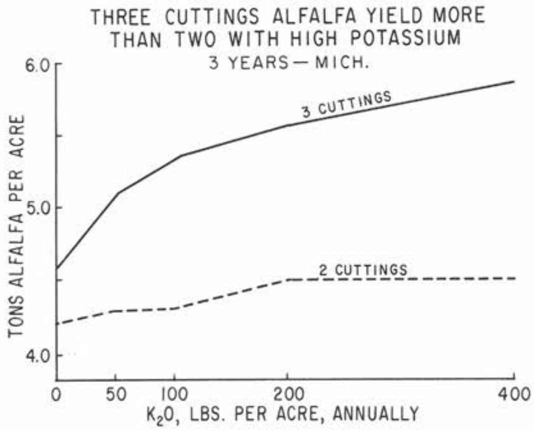
This indicates 4 cuttings, with the last cutting in mid-October after growth has stopped, will not hurt the stands. And it will produce the highest yields because of younger leaves and less leaf loss.

More frequent cutting gives finer, leafier, more digestible hay. This improves feeding value 50% or more. And animals eat more of it—the ultimate test for any feed.

In a 4-year Michigan test, unfertilized Vernal cut twice a year yielded 3 tons hay per year. A French variety, receiving 200 lbs K_2O each year and cut three times, yielded 4.9 tons a year —a 63% jump in yield. But feed value almost doubled—92% increase per acre.

KEY 2—TOPDRESS ANNUALLY, ESPECIALLY WITH POTASSIUM. Early, more frequent cutting gives higher yields. It also takes off MORE potassium —because young-cut alfalfa plants contain higher potassium than older plants cut less frequently. **RECOMMENDATION:** Apply 12 lbs phosphate (P_2O_5) and 50 lbs potash (K_20) for every ton removed. Calculate fertilizer applied with the seeding in the total amount applied. For example, 5 tons need 60 lbs phosphate and 250 lbs potash. Eight tons need 96 lbs phosphate and 400 lbs potash.

When high potassium rates are applied, they should be applied in split



applications annually for best yields. Over 200 lbs K_2O annually should be split between a fall application and after the first cutting.

Phosphorus tends to carryover more and can be applied annually or every other year without reducing yield. Add 1 to 2 lbs boron per acre each year, especially on coarse-textured soils of high pH.

WHY DO WE NEED TO APPLY THESE AMOUNTS OF A P AND K? Many MSU tests have shown yields going up as annual K_20 increases to about 400 lbs per acre, see graph. Tests in other areas are telling the same story.

Also, yields increase as P is added if soil tests indicate a need. A 1976 MSU test showed 8 tons of Saranac alfalfa removing 14 lbs of P_20_5 and 47 lbs of K_20 in each ton of hay. This means this 8-ton hay yield removed 112 lbs phosphate and 376 lbs potash per acre.

To get more cuttings and good winter survival, alfalfa must be well fertilized, particularly with potassium.

KEY 3—USE EARLY MATURING, RAPID RECOVERY, WILT-RESISTANT VARIETIES. Alfalfa varieties should be chosen for (1) yield goal, (2) stand life desired, (3) soil conditions, (4) seed availability, (5)

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Do you want to continue to receive Better Crops magazine? Give us your frank views below. This is a good time to tell us how to improve it. We have a new editor to bring fresh ideas to your suggestions.

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Please put any other comments, suggestions, criticisms, etc., you wish to make in the space left here and send to Potash & Phosphate Institute, 2801 Buford Hwy., N.E., Suite 401, Atlanta, Georgia 30329.

CUT ALONG DOTTED LINE

FROM PAGE 10

intended use—for hay (or silage) or pasture.

For maximum yield, short-to-medium term varieties run 2 to 4 years. Many commercial and public varieties have been fine for this. More than 75% of the alfalfa in the North Central area is left for 3-4 years, generally followed by corn. Most of these varieties are earlier maturing. They are less winter-hardy than Vernal but hardy enough for highest yields for 2-4 year stands.

Select best variety from local recommendations. Wilt resistance is a must. Almost all varieties used today can resist wilt. Your agricultural leader will know the ones for your area.

For hay or pasture, long-term varieties run 5 years or more. Use North American types to resist winter and wilt. They start to blossom in late May or early June in southern Michigan. They are fine stemmed. They recover moderately after cutting. And have moderate fall dormancy. Many varieties are available. Study variety test results and follow state recommendations.

Michigan State University trials have shown how widely alfalfa varieties can vary in yield. For example:

In East Lansing: Conover loam, pH 7.0. Ranging from 6.2 to 9.1 tons, 4-year average, 4 cuts per year.

In East Lansing: Brookston loam, pH 7.2. Ranging from 4.0 to 7.7 tons, 8-year average, 4 cuts per year.

In Battle Creek: Kalamazoo sandy loam, pH 6.9. Ranging from 2.2 to 5.2 tons, 7-year average, 2 cuts per year.

In Upper Peninsula: Silt loam, pH 6.8. Ranging from 4.2 to 5.3 tons, 3-year average, 2 cuts per year.

These yield ranges can make a 35% to 50% difference in what you haul out of the field. Selecting the right yielder is obviously important.

KEY 4—SPRAY TO CONTROL ALFALFA WEEVIL WHEN NECESSARY. Follow recommendations to control harmful insects, including alfalfa weevil and leafhopper.

A first cutting taken about May 25-30 in southern Michigan usually doesn't need spray against weevils. This is one of the advantages of early cutting. Spraying stubble after first cut is removed is necessary in most southern Michigan fields every year.

Many farmers now produce 4-6 tons alfalfa per acre—some of the best 6-8 tons per acre in a four-cut system. A 7-9 ton yield requires four cuttings in Michigan. Three cuts won't get the highest yields.

How about protein? It's expensive to purchase and will become more expensive in the future. Alfalfa is a great protein provider.

A 6-ton alfalfa yield of 20% protein carries one ton of protein. Eight tons have 2,700 lbs of protein.

When used to supply protein for a dairy herd, 6-8 tons alfalfa is the cheapest source of protein, including soybeans. Michigan tests showed 8 tons Saranac alfalfa per acre containing 460 lbs N. This provides 2,760 lbs of protein.

Where did this nitrogen come from? Probably 50 to 75 lbs from the soil. About 400 lbs from the air through alfalfa's nitrogen factory, symbiotic fixation.

AS ALFALFA YIELDS go up in the next decade, phosphate and especially potash applications will have to increase even more than the percentage increase in yield.

P and K hunger signs can be rather subtle in alfalfa. The signs may go undetected until yields and stands drop. To maintain 6-8 tons or higher alfalfa yields, the grower must use more than normally applied from 5-6 ton range.

Inadequate sulfur may limit future Michigan yields, as in some less industrialized states, especially on coarse-textured sandier soils.

Sulfur that once came from industrial plants burning coal is now being scrubbed away to meet EPA clean air standards. And S deficiencies are showing up in some alfalfa fields. **The End**

Foods Instead of Drugs To Offset Potassium Losses In Diet

EDITOR'S NOTE: This article was developed by Bill Agerton from a detailed article in the September 1976 issue of Utah Science.

EAT THE RIGHT foods to replace body potassium lost when diuretics are used. Utah State University experts say foods instead of extra drugs can offset these potassium losses.

Increased use of diuretics has caused potassium loss to become a common medical problem in recent years. And potassium is vital to human health.

What are diuretics? They are drugs used to accelerate urine formation in the human body so excess body water can be excreted. Medical doctors often prescribe the drugs for persons with congestive heart failure, high blood pressure or liver abnormalities.

But, doctors cannot always prevent problems for their patients who use diuretics even when they carefully match patient and situation. Why? Each diuretics's mode of action and potential side effects are different. And the more potent the diuretic, the more significant the potassium loss. The exception . . . some diuretic drugs have little effect on potassium.

THE CURRENT TREATMENT for potassium deficiencies is to combine supplemental potassium salts and potassium-sparing diuretics. The side effects of potassium salts include irritation of the upper small intestines while a number of side effects may accompany the diuretics. The latter may cause elevated blood urea nitrogen, dizziness, vomiting, diarrhea, flaccid weakness, etc.

The Utah nutritionists and chemists recommend a qualitative diet therapy. By properly selecting foods, a person can offset potassium depletion problems. In fact, a lack of daily intake of potassium can be a problem before a person encounters illness or drug therapy. Daily intake may be as low as 50 milliequivalents (1950 mg) where 100 milliequivalents are needed.

EATING YOUR WAY OUT of a potassium deficiency certainly seems more pleasant than taking drugs to do it. But, how much should a person eat? Doctors often fail to provide instructions about quantity of potassium rich foods needed to replace that lost to drugs. In fact, it has been difficult to determine just how much potassium different foods actually provided.

Now there is a method for determining the nutrition/energy ratio—index of Nutritional Quality (INQ). The USU authors devised a computer program that allows calculation and summary information in graph form for hundreds of foods. Sodium is included in the computed data because it sometimes is lost at the expense of conserving potassium in the body.

The Utah information can help patients everywhere who need potassium supplements. In the ratings, foods with a computed INQ above "1" were considered good choices. This indicated that the amount of that food required to supply a person's total energy requirements for a day (2,300 Kcal) should also supply the needed potassium. Foods rating lower than "1" were considered poor choices.

WHAT ARE SOME of the best foods identified by the program?

Foods high in potassium and sodium include yogurt from skim milk, butter, canned cod, baked flounder, canned sardines, scallops, and Swiss chard. Chili con carne was high in sodium, but was not found to be a best choice for potassium content (INQ less than 1).

Other foods high in potassium and considered a best choice include: the fishes, chicken, some beans, avocados, potatoes and potato salad, bananas, fruit cocktail, grapefruit juice, orange juice, melons, canned pears, prunes and raisins.

Foods moderately high in potassium but still considered best choices included bass, clams, asparagus, green beans, beets, broccoli, Brussel sprouts, cabbage, cauliflower, sweet corn, eggplant, lettuce, peas, mashed potatoes, summer squash, tomatoes and tomato juice, a variety of berries, grapefruit, peaches, strawberries, and instant tea.

Some moderately high potassium foods found to be high in sodium were artichoke, beets, carrots, pickle, sauerkraut, spinach, beef and chicken broth and some other soups.

Foods low in potassium and high in sodium but still a good choice were celery and catsup. Bacon and sausage links were determined to have high sodium.

Physicians, dietitians and nutritionists are using the information in their counseling of persons with diverse dietary problems.

The End

200+ Bushels Per Acre CORN YIELDS In The United States

DAVID DIBB
and
W. M. WALKER*
University of Illinois

NOT TOO LONG AGO, 100 Bu/A corn was an uncommon yield—and often considered impossible.

But in recent years, whole states have averaged 100 Bu/A corn in the U.S. In 1978, the 68 million acres of corn in the U.S. reported an average yield of 101 Bu/A across the nation.

Yields exceeding 200 Bu/A are frequently observed. What does it take to reach 200 bushels of corn per acre?

The Potash & Phosphate Institute conducted a nationwide survey of agriculturists, both producers and researchers, to determine some crop production practices associated with 200+ bushel per acre yields. This report summarizes observations from the survey.

THE SURVEY includes 549 reports of 200+ Bu/A corn received from 33 states across the U.S. A letter asked university research and extension personnel, consulting services, seed corn companies, state and national corn grower organizations to identify any 200+ bushel yields they knew of and the steps taken to get them.

As the producers' names were received, a letter was sent directly to each producer or researcher for the exact production practices in their program. Approximately 50% of these inquiries were answered.

The survey covers the 1975 and 76 growing season, generally, though a few other entries are included. Only a small proportion of the total number who produced 200+ bushel yields in these years is finally included in the survey, response from the initial survey group indicates.

But the sample does give a good summary of basic practices employed in

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*Dr. Dibb is Southern Midwest Director of the Potash & Phosphate Institute. Dr. Walker is Professor of Biometry and Soil Fertility, University of Illinois.

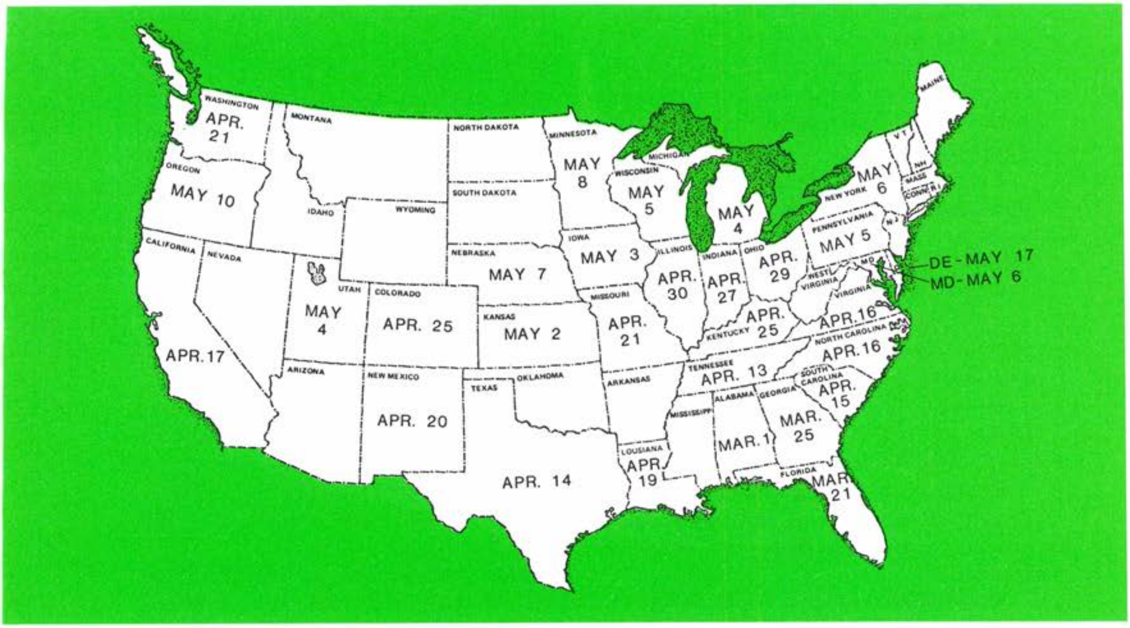


Figure 1—Average planting date of 200+ bu/A corn yields by state.

producing 200+ Bu/A corn, as reported by these producers. **Table 1** shows average management practices from 549 reports where corn yields equaled or exceeded 200 Bu/A. The average yield was 218 Bu/A, 352 Bu/A the highest.

HYBRID SELECTION is an important step in reaching 200+ bushel yields. Several different hybrids were used, the survey showed.

If other management factors are adequate for a 200+ bushel yield, several hybrids contain the genetic yield potential that is necessary. Commercial and public corn breeders will continue to develop even better hybrids for the future.

Table 1. Average management practices by region that were associated with 200+ bu/acre corn yields throughout the U.S.

		Region*				
	Overall	West	Great Plains	Midwest	Northeast	Southeast
Yield bu/A	218	220	219	216	217	221
Planting date	Apr. 22	Apr. 17	Apr. 27	Apr. 29	May 6	Mar. 28
Harvest population	25,500	27,350	26,300	24,400	23,950	25,550
Fert. rate (N-P_2O_5-K_2O)	220-95-109	227-65-61	234-59-29	204-120-144	184-90-93	258-113-172

*West: CA, OR, WA, UT; Great Plains: CO, KS, OK, NE, NM, TX;
Midwest: IL, IN, IA, KY, MI, MN, MO, OH, WI; Northeast: DE, MD, NJ, NY, PA, VA;
Southeast: AL, FL, GA, LA, NC, SC, TN, MS.

PRECISION PLANTING is important. The producer can generally control his corn plant population. Harvest populations ranged from 16,000 to 47,000 plants per acre, averaging around 25,500 plants per acre.

Let's assume each stalk produces a 0.5 pound ear of corn, the predicted yield for 25,500 plants per acre is 228 bushels, not much more than the survey average of 218 Bu/A.

Although plant populations averaged a high 25,500 plants per acre, a statistically important (2=.0001) correlation was observed between plant population and yield. This places the **higher yields with the higher plant populations.**

Research has often shown this. Research has also shown uniform spacing in the row can increase yield potential further.

Row widths ranged from 18 to 48 inches, averaging 33.1 inches among the 200+ bushel corn growers. There was no significant correlation between row width and yield. But research has shown narrower row widths may be an important consideration for increasing yields.

FERTILIZER APPLICATIONS were associated with the higher yields. Soil test reports varied so much—soil test differences, different extractants, different category limits and different soil fixation properties—that they did not give a good statistical comparison of P and K application rates and yield.

But soil P and K levels were generally high or very high and average application rates were 95 lbs of P_2O_5 (about 42 lbs of P) per acre and 109 lbs of K_2O (about 89 lbs of K) per acre. This exceeded somewhat the grain removal.

At some locations, the reported soil test and accompanying P and K rates applied indicated P and K may have limited obtaining even higher yields than reported.

Soil pH, a measure of soil acidity, averaged 6.7, which is within a desirable range for corn production. Soil pH varied from 5.5 to 8.3, with only two observations below pH 6.0 and 5 above 8.0. There was no important association between pH and yield.

The average nitrogen rate was 220 lbs/A. The relation between N rate and yield was statistically significant (2=.0001). That is, higher yields went with higher N rates. Inadequate nitrogen may have limited an even higher yield than the one reported for some locations.

MOISTURE IS POTENTIALLY the most limiting factor in corn production. But, with other factors being at adequate levels, it was adequate to produce at least 200 bushels in each case. Moisture stress was probably the limiting factor to even higher yields in some locations.

Table 2 shows the percentage of the 200+ Bu/A yields that were irrigated in each region of the nation to see the relative extent that inadequate rainfall limits high yields in each region.

Table 2. Percent of 200+ bu/A yields reporting use of supplemental irrigation.

Region	% irrigated
West	100
Great Plains	96
Midwest	15
Northeast	27
Southeast	45

The arid and semiarid West and Great Plains rely heavily on irrigation for high yield potential. The Midwest generally receives adequate quantity and distribution of rainfall. The Southeast is noted for generally high annual rainfall. But the problem of seasonal distribution and generally lower soil moisture holding capacities require greater dependence on supplemental irrigation for high corn yields.

Fertility is important when discussing moisture limitations because research has shown the advantage of adequate fertility in overcoming short term moisture stress periods. The high fertility reported in this survey helped moderate the effects of short term moisture stress on yields as they occurred.

EARLY PLANTING has been supported by research and has been a recommended practice in the U.S. for several years.

This survey supports the importance of early planting. The average planting date was April 22, relatively early given extreme north to south distribution of the yields.

Across this large distance there was no statistical association between planting date and yield. But within any one state or part of a state, research has shown earlier planting dates can generally increase corn yield potential.

A subjective look at these planting date data seems to indicate critical planting date for high yields becomes much narrower as you move from south to north and into the traditional Corn Belt.

For example, of the 51 planting date observations in Illinois, the earliest was April 13 and the latest May 17 (34 days). Of 35 observations in Georgia, the earliest was March 1 and the latest May 10 (70 days).

This probably comes from the need to plant as early as possible in the north to allow for tasseling and silking to occur as nearly as possible to the time of maximum solar radiation in late June.

Higher radiation and photosynthesis rates can then produce higher yields. Because the dropoff from this radiation peak is much more rapid as you move northward, early planting becomes more and more critical. Weather data also shows the mid Corn Belt has a much lower probability of a 1″ rainfall during early July than in late June. This indicates earlier pollination, due to earlier planting, would more often help avoid effects of severe moisture stress at this critical period.

Average planting date was still much earlier in Southeast than in Midwest, although the range was much greater. Average planting date is relatively early for each separate state, shown in **Figure 1.**

Acreage involved in the 200+ Bu/A yield ranged from 1 acre to 190 acres, averaging 6.1 acres. Analyzing the association between acres measured and reported yield did not result in an important correlation. So, size of measured area was **not** a major factor associated with yield.

IN SUMMARY, 200+ Bu/A corn yields can come from a rather wide range of plant populations. But statistics show high yields tied to high plant populations. And nitrogen rate was important to corn yield. Inadequate nitrogen may have limited even higher yield than the one reported from some locations. High P and K levels and moderate pH were also generally associated with these high yields.

Other production practices not evaluated in the survey are also important for reaching 200+ bushel corn yields.

Weeds must be controlled so they do not compete with corn for moisture and nutrients. In areas where they are a problem, diseases and insects can prevent 200+ bushel yields.

They may be controlled through various recommended techniques such as variety selection, planting date, or use of biological and/or chemical agents. Timeliness and precision operations are important contributors to increased yield potential.

Although some regions had many 200+ bushel sites that were irrigated, in many areas climatic factors are not controlled by the producer or researcher.

For a producer who would like to approach or exceed 200 Bu/A corn, it is important to maintain all factors under his control at sufficient levels to take advantage of a favorable climate when it occurs, whether irrigated or not. **The End**

Do you want this magazine to continue to come to you? See Page 12.

Beating The Odds with HIGH CORN YIELDS

WILLIAM WALKER
University of Illinois

MANY CORN PRODUCERS can still remember when yields of 100 to 125 bushels per acre were considered "high"—and impossible by a few.

The current record yield is 352 Bu/A, although just a few producers have reached 150 to 200 Bu/A. And 250 Bu/A or more usually stand at the top or near the top of most major corn-producing sections of the U.S.

A reliable "prescription" cannot be written for extremely high corn yields like 300 Bu/A in today's technology. Factors affecting yield vary enough to make such prescriptions quite speculative. Yet researchers and corn producers are continually learning more about corn production. And 300 or more Bu/A may be achieved in the future.

Figure 1 shows a normal frequency distribution where the average corn yield is 226 Bu/A and the standard deviation is 51 Bu/A, based on yields obtained by Mr. Herman Warsaw for the growing seasons of 1967 through 1977.

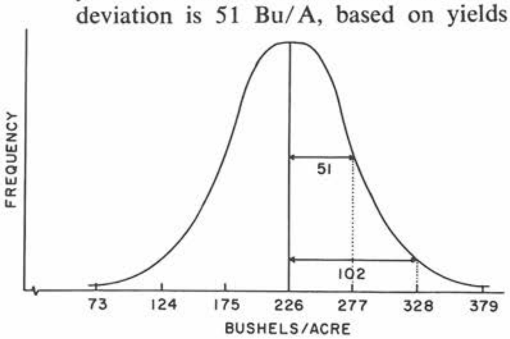


FIGURE 1

If the history of corn production on Mr. Warsaw's field repeats itself (that is, if the distribution of corn yields in **Fig. 1** is correct), then the probability of 300 or more Bu/A is about 7 in 100. But if the average corn yield is 250 Bu/A, the probability of 300 or more Bu/A is increased to about 16 in 100.

If the average corn yield happened to decrease, then the probability of a 300-or-more Bu/A yield would decrease. The probability that any particular corn grower would produce a 300 or more Bu/A corn yield within any given year is improved if average yield over a period of years is high.

Let's review some practices associated with high corn yields.

SITE SELECTION is important. Select a site with deep permeable soil that will allow full development and proliferation of plant roots. It should also permit maximum water infiltration and have the texture of silt loam or clay loam to have high plant-available soil moisture.

If possible, select a site with soil relatively well supplied with organic matter, not only in the plow layer but deeper in the soil profile.

Soil physical properties can affect yield. And favorable site selection is a key decision in achieving unusually high crop yield. A well drained permeable soil not only permits top root development, but also favors the plant's uptake of essential nutrients.

SOIL FERTILITY should be high —either through buildup by fertilizer use or weathering of soil minerals. Aim for a soil pH between 6.5 and 7.0.

A recent survey of 275 Midwestern sites producing 200+ Bu/A showed an average soil pH of 6.7. A slightly acidic soil pH should be a desirable environment for corn roots. Use soil tests to guide fertilizer applications.

Soils testing high P-K should receive at least 50 to 75 lbs P and 100 to 150 lbs K broadcast before planting. Since the special corn-producing area should be relatively small, economic considerations are minimal.

Remember nutrient uptake. Each corn grain bushel contains about 0.8 lbs nitrogen, but some N is also required for the vegetative portion of the plant. One rule of thumb is 1.2 to 1.3 lbs nitrogen per bushel of corn.

This suggests 375 lbs N per acre. If animal manure is available, apply 10 to 20 tons/A and assume 50 to 100 lb N from this source. Then apply 100 lb N before planting and 200 lb N sidedressed about 3 to 4 weeks after seeding.

Using nitrogen to get high corn yields deserves special thought and consideration. If the soil becomes wet for just a few days, available soil and fertilizer nitrogen may change to nitrogen gas and be lost to the atmosphere.

And in coarse-textured soil, nitrogen may leach through the soil profile out of the rooting zone. Observation is the first key to scientific method. This key must be used in managing the N nutrition of the corn plant. A symptom of nitrogen hunger is the yellowing of corn leaves. Additional nitrogen should be sidedressed.

What about calcium, magnesium, sulfur, and the micronutrients? If the soil is limed to pH 6.5 to 7.0, sufficient calcium will be available for high yields. If the soils are low magnesium, use dolomitic limestone to adjust soil pH.

Commercial fertilizers, such as magnesium sulfate or potassium sulfate supply magnesium and sulfur. Potassium sulfate also supplies potassium.

Some soil testing labs will determine the micronutrient status of a soil through soil test procedures. In the Midwest, micronutrient soil tests have not calibrated with yield as satisfactorily as the more conventional analyses for P and K.

Chemical tests of the plant or leaf tissue can help monitor the nutritional status of the crop for all needed nutrients during the growing season.

PLANT EARLY in the growing season. Having corn plants near or at silking the last week of June or first week in July is desirable in the central U. S.

Use narrow rows and equidistant spacing between rows and between plants in the row, as nearly as possible. Equidistant spacing gives many benefits. For example, nearly complete ground shading early in the growing season causes less moisture evaporation and less weed growth.

Planting 28,000 to 33,000 plants per acre of an adapted variety should increase the **potential** for high corn yields. Check variety trial publications and seed dealers for assistance in selecting a variety.

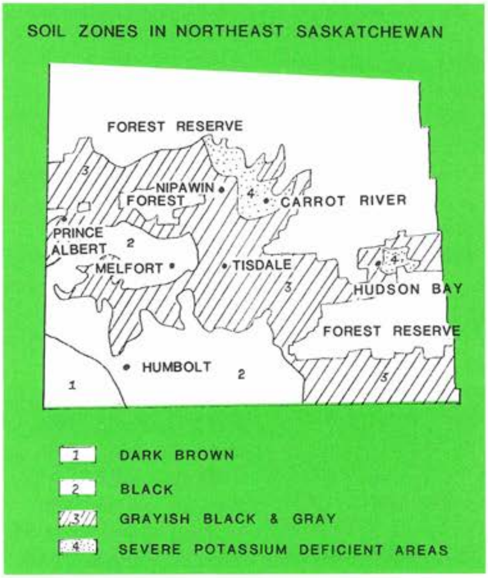
CONTROL WEEDS and other pests. Don't expect maximum corn yields when weeds are using available moisture and nutrients. Also, right selection of variety of use of pesticides reduce the effects of plant diseases and insects.

WILL YOU GET a high yield such as 300 Bu/A if your farm has a soil with all the desirable properties and you do all the things recommended?

Obviously your odds are much better when you use all the knowledge available. At such high yield levels, small differences in daily temperatures, light intensity, rainfall amount and distribution, and soil fertility can cause relatively large yield differences.

If you maintain the controllable part of your environment at an optimum, you are ready to take advantage of the uncontrollable part when it is favorable. **The End**

POTASSIUM DEFICIENCIES In Northeast Saskatchewan



ROY BUTTON
Saskatchewan Dept. of Agriculture

ABOUT 1,000,000 ACRES of Saskatchewan soils are estimated by soil tests to be deficient in potassium.

The largest percentage and most severely deficient soils are in the northeast area of Saskatchewan.

The Grayish Black and Gray soils in the higher rainfall or more northerly regions contain less available potassium than soils in the black, dark brown, and brown soil zones, shown in Figure 1.

From 10 to 20% of the Grayish Black and Gray soils tested by the Saskatchewan Soil Test Lab contained less than 180 lbs available potassium in the top 6″ of soil, **the level where potash fertilizers are recommended for producing barley.**

Up to 6% of the tested Black soils and less than 1% of the tested Brown and Dark Brown soils required potash.

MAINLY COARSE OR SANDY SOILS with low clay contents require additional potassium. Table 1 shows 22% of the stubble fields and 17% of the fallow fields on the coarse textured Grayish Black soils and only 10% of the stubble fields and 7% of the fallow fields on the fine textured soils contained less than 180 lbs of available potassium in the top 6″ of soil.

Similar, but more pronounced results, occurred in the Gray soils.

Figure 1 shows the most severe potash deficient soils in Saskatchewan to be in the Carrot River soils. Soil tests show 75 to 85% of the Carrot River

TABLE 1: Percentage of the soils deficient in potassium for the production of barley in Gray Black and Gray soil zones. (Saskatchewan Soil Test Lab Data—1977-78)

Soil Texture	Grayish Black		Gray	
	Stubble	Fallow	Stubble	Fallow
Coarse	22	17	23	15
Medium	11	13	10	0
Fine	10	7	2	0

soils need added potash to produce barley.

About 100,000 acres of this soil are cultivated in the Nipawin, Carrot River, and Hudson Bay areas. The coarse to medium textured Carrot River soils have many peaty areas, high water tables, and high surface lime contents—all factors tied to potassium deficiency in soils.

DIFFERENT CROPS need different amounts of soil potassium to get maximum production. Barley requires more potassium than wheat, oats, or rape.

Legume crops are heavy potash users. They require 240 lbs of available soil potassium in the top 6″ of soil at establishment time, according to Saskatchewan Soil Test Recommendations.

Up to 35% of the Grayish Black and Gray soils and up to 20% of some of the Black soils require potash for the production of legume crops.

POTASH DEFICIENCIES occur on both summerfallow and stubble crops. Stubble crops tend to show more of it, in Table 1. This is expected since some stubble fields are cropped continuously for 3 or more years, which can deplete the soil potassium supply.

Farmers are becoming more conscious of the need for potash fertilization in Northeast Saskatchewan. The area commonly grows barley and legume crops, both heavy potash users.

With late seeding from wet spring conditions and the risk of fall frosts, barley is often preferred over wheat because of barley's earlier maturity. The area grows Red Clover, Sweet Clover, and Alfalfa for seed. About 100,000 acres of alfalfa is produced for the Alfalfa Dehy Industry.

FARMERS USUALLY boost barley production 25-30% from using potash fertilizer on deficient soils. Wheat and rape tend to vary in their responses to added K but generally give economic response when soil K level drops below 150 lb per acre.

Lack of potassium has actually led to complete crop failures on severely deficient soils in the Carrot River area, especially on fields seeded to barley.

University of Saskatchewan research and other work have found it more efficient to drill potash with the seed of cereal crops than to broadcast potash. This is why most farmers drill P and K with the seed and broadcast N where needed.

EXTRA POTASH is broadcast on severely deficient soils to increase soil K levels. Potash is usually broadcast for rapeseed to get adequate K levels and avoid seedling damage from seed placed fertilizer.

The only effective way to determine deficiencies is to soil test, because just a percentage of the fields are deficient in K and similar soils can vary widely in their available K levels.

We encourage farmers to have their fields soil tested and fertilized according to soil test recommendations.

Northeast Saskatchewan may well increase its use of potash fertilizers in the future. Certain cropping practices—longer term rotations, legume crops for soil improvement, and more legume seed production—may deplete soil K reserves and increase the need for potash fertilization. **The End**

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SEE PAGE 12

Seeding Orchardgrass Into Alfalfa
SUCCESSFULLY

From Forage and Grassland Progress Of The American Forage and Grassland Council.

C. L. RHYKERD,
B. O. BLAIR,
and N. P. MAXON
Purdue University

OVERSEEDING unproductive pastures and hay fields with a legume is one of the most commonly recommended methods of improving hay crop yields.

But situations arise which make it desirable to seed a cool-season grass, such as orchardgrass into an established alfalfa field.

Undoubtedly, the most common reason for this is that as alfalfa stands age they become less productive due to thinning of the stand. The recently developed technique of "clear seeding" alfalfa, involving application of the herbicides Balan, Eptam or Tolban, dictates that only alfalfa can be seeded since these herbicides kill many grasses.

There are occasions where a pure stand of alfalfa is required such as for dehydration, or it may be desirable for milk production.

However, there are many advantages of including a cool-season grass in a mixture with alfalfa. A little grass with alfalfa is preferred by many for feeding horses.

ADVANTAGES OF alfalfa-grass mixtures include:

- **Reduced soil erosion, thereby minimizing non-point pollution.**
- **Reduced winter heaving of alfalfa.**
- **Less weed invasion.**
- **Reduced bloat hazard.**
- **Less lodging of alfalfa.**
- **More rapid curing of hay.**
- **Easier preservation when stored as silage.**

As little, if any, research has been reported relative to the feasibility of seeding orchardgrass into an established stand of alfalfa, the following experiment was conducted on the Purdue University Agronomy Farm, West Lafayette, Indiana.

A 5-year-old stand of Temp alfalfa was selected for overseeding Hallmark orchardgrass, at a seeding rate of 10 lbs/A as follows:

1. Seeded September 24, 1975, with a Nordsten grain drill.

2. Frost seeded on March 26, 1976.

3. Seeded April 2, 1976, with a John Deere Power-Till Seeder.

Tiller counts were taken following

Table 1. Effect of method of seeding orchardgrass in established alfalfa on orchardgrass tillers/m². Tiller counts were taken in June '77.

Seeding Time	Orchardgrass* Tillers/m²
Late Summer-1975	1188
Frost Seeding-1976	631
Spring Seeded-1976	950

*Average of 3 replications

the first cutting of the second growing season for the orchardgrass, and the data are presented in **Table 1.** No attempt was made to evaluate the stand in 1976 as the spring-seeded seedlings were slow to establish. The 1975 late-summer-seeded orchardgrass plots made vigorous growth in 1976, indicating successful establishment.

The data presented in **Table 1** demonstrate that all methods of seeding orchardgrass into the alfalfa were successful. In fact, it was evident from observing the plots during the growing season in 1976 that the seeding rate for the late-summer-seeded and the spring-seeded orchardgrass may have been too high, as these two methods of seeding resulted in vigorous competition for the alfalfa.

THESE RESULTS show late summer to be a better time to seed orchardgrass into an established alfalfa stand in Indiana than in spring. One of the factors favoring late-summer seedings is the cool temperature at this time, along with adequate rainfall.

In addition, adopted alfalfa varieties produce a rosette-type growth during fall, thereby offering less competition to the orchard grass seedlings. Alfalfa makes vigorous growth during spring and, consequently, offers a great deal of competition to the seedlings for moisture, nutrients and sunlight.

Generally, agronomists do not recommend late summer seeding of orchardgrass, due to lack of winter hardiness in orchardgrass seedlings. There was no evidence of winter killing of seedlings in this experiment. Quite possibly the established alfalfa plants provided some microclimatic protection to the orchardgrass seedlings.

Based on the results of this study, a late summer seeding rate of orchardgrass of 5 lb/A should be adequate when seeding into an established alfalfa stand. The 10 lb/A seeding rate appeared optimal for the frost seeding, while 5-7 lb/A should be sufficient for spring drilling of orchardgrass into established alfalfa.

SOME SOIL COVERAGE of the orchardgrass seed was provided by the Nordsten grain drill and the John Deere Power-Till seeder. Based on the data from this investigation, use of seeding equipment providing some soil coverage of the seed would appear advantageous in establishing a cool-season grass such as orchardgrass.

A word of caution to those attempting to sod-seed orchardgrass into alfalfa. One of the major causes of thinning of alfalfa stands is lack of sufficient K. Since orchardgrass is more efficient at absorbing K than alfalfa, it may be necessary to make a liberal application of K each year.

Otherwise, the orchardgrass will crowd out the remaining alfalfa plants. A ton of hay removed 50-60 lb/A of K_2O. This fact, along with a soil test, should be used as a guide in applying K fertilizer to an alfalfa-orchardgrass stand. **The End**

LET US KNOW . . .

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SEE PAGE 12

SOYBEANS REQUIRE adequate quantities of phosphorus for plant growth. Although phosphorus is an essential element for plant growth, we don't often recognize unique functions this nutrient performs within the plant nor how it influences plant composition of the other two primary nutrients, nitrogen and potassium.

It is generally believed in the U. S. that it is not necessary to apply phosphorus for soybeans when they follow such crops as corn or wheat, because little or no response would occur.

This may be true in some situations. But we must understand that soybeans demand adequate phosphorus to grow. This was well shown in Brazil. As soybean production moved to low fertility soils, phosphorus influenced nodulation.

Soybeans Need PHOSPHORUS

R. G. HANSON
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RESEARCH ON SOME low phosphorus soils in south-central Brazil studied the effects of P on nodulation, leaf composition of the plant, and yield.

Table 1 shows results from a field study near Anapolis, Goias, Brazil. Phosphorus influenced nodule weight and numbers per twenty (20) plants and yield more than limestone did.

Including limestone with P produced more nodules per plant, a larger nodule mass, and higher yields than without lime. This demonstrates phosphorus with lime produces greater soybean growth and yield than limestone alone on these low fertility acid soils.

HOW DO PHOSPHORUS sources affect nodulation, yield and the NPK composition of the leaf and seed? The National Soybean Research Center near Londrina, Parana, Brazil studied this.

These soils are considered low to medium in available P and not the most infertile in southern Brazil.

This study included triple superphosphate, rock phosphate of Morocco and recently discovered Brazilian rock phosphate called Patos de Minas.

In this study, additional phosphorus increased nodule numbers and mass per plant, regardless of source. The more soluble triple superphosphate produced higher yields and at lower rates.

The influence of phosphorus treatment on leaf and seed composition is very interesting. Increasing quantities of phosphorus boosted both leaf and seed N-P regardless of P source. Increasing P rates did not increase leaf potassium but it did raise K level of the seed.

THESE TWO STUDIES clearly show phosphorus can influence soybean nodulation. This is important because higher nodule population and total nodule mass can aid nitrogen fixation and other plant functions to help increase yield.

Phosphorus increased both N and P composition of the leaf and the seed. We should also note phosphorus increased the K level of the soybean seed as well as nitrogen and phosphorus.

This suggests phosphorus and potassium removal increases with high yields and these high yields need higher maintenance fertilizer applications.

Soil testing and plant analyses are important tools for determining soil P levels and plant nutrient status of the soybean crop. **The End**

Table 1. Effect of phosphorus and lime upon soybean nodulation, leaf N, P, K and yield.

P-Treatment	Nodulation (20-plants) Weight	Number	Leaf Composition N	P	K	Yield
Kg P_2O_5/ha	g			%		Kg/ha
Without lime						
0	0.18	85	3.92	0.19	1.77	453
200	1.15	200	3.94	0.21	2.23	1,527
400	2.05	320	4.14	0.25	2.39	2,038
600	2.08	451	4.32	0.27	2.11	2,382
800	2.15	357	3.92	0.27	2.01	2,326
With Lime						
0	0.21	98	4.40	0.18	2.04	619
200	1.22	192	4.15	0.22	2.29	1,921
400	2.07	366	4.30	0.26	2.11	2,288
600	2.21	354	4.05	0.25	2.19	2,510
800	2.24	483	4.19	0.28	2.26	2,685

Anapolis GO - Brazil. Pereira, Hanson, Dutra, Franca and Santos.

For Adequate Nodulation

Table 2. Effect of phosphorus sources upon soybean nodulation, yield and N, P and K composition of leaf and seed.

P-Treatment	Nodulation (20 plants) Weight	Number	Leaf Composition N	P	K	Yield	Seed Composition N	P	K
Kg P_2O_5/ha[1]	g			%		Kg/ha		%	
TSP									
0	4.16	1,296	4.97	0.21	2.38	2,658	6.23	0.41	2.07
80	4.87	1,525	5.33	0.24	2.45	3,071	6.46	0.49	2.18
160	4.95	1,400	5.31	0.25	2.26	3,390	6.53	0.58	2.11
320	4.22	1,526	5.45	0.28	2.21	3,448	6.53	0.56	2.23
640	4.73	1,470	5.42	0.32	2.32	3,585	6.38	0.60	2.30
RP-Morocco									
0	4.16	1,296	4.97	0.21	2.38	2,658	6.23	0.41	2.07
80	4.92	1,377	5.37	0.25	2.38	2,994	6.45	0.49	2.14
160	5.48	1,667	5.40	0.28	2.37	3,449	6.53	0.56	2.20
320	5.75	1,681	5.57	0.27	2.32	3,501	6.78	0.59	2.27
640	4.88	1,541	5.44	0.26	2.15	3,316	6.38	0.61	2.33
RP-Brazil									
0	4.16	1,296	4.97	0.21	2.38	2,658	6.23	0.41	2.07
80	4.68	1,501	5.21	0.24	2.30	3,051	6.43	0.49	2.16
160	5.87	1,605	5.35	0.23	2.35	2,977	6.45	0.47	2.18
320	5.86	1,861	5.48	0.27	2.33	3,229	6.39	0.52	2.15
640	4.96	1,699	5.65	0.28	2.17	3,512	6.63	0.55	2.27

Londrina, PR-Brazil. Hanson & Borkert. EMBRAPA CNPSoja.

[1]TSP — Triple superphosphate; Rp-Morocco — Moroccain Rock Phosphate; RP-Brazil — Rock Phosphate-Patos de Minas, Brazil.

Nitrate Accumulation In Corn And Nitrate In Animals

C. H. NOLLER and
C. L. RHYKERD
Purdue University

NEARLY EVERY SUMMER concern is expressed over the threat of nitrate toxicity — especially in isolated areas where low rainfall prevents economic yields of corn grain and the crop is harvested for silage.

The threat of nitrate toxicity is due to a combination of factors. The farmer has probably applied at least 150 lb N/A, in expectation of favorable rains for high grain yields assuming other factors are optimum.

Lack of rain stunts the corn plant and increases possibility of high nitrate concentration in the plant.

High nitrate concentrations are not particularly harmful to plants. And if growing conditions improve, especially moisture, nitrate concentration will probably decline. Danger from high nitrate plants comes when the forage is fed to animals.

Let's look at Purdue University trials which fed cattle and sheep corn and sudangrass fertilized with up to 800 lb N/A.

NITROGEN AND THE PLANT. When growing conditions are favorable, the corn plant takes up nitrogen largely in the form of nitrate. The nitrate is then rapidly converted to ammonia which is incorporated into amino acids and then to protein.

So there is usually a rather low concentration of nitrate in the corn plant. But unfavorable growing conditions, such as drought, can interfere with nitrogen assimilation in the plant. This can cause the nitrogen to accumulate in the plant as nitrate—particularly in the stalk.

When conditions improve, there may be a very rapid utilization of the nitrate, sharply reducing plant nitrate in just a few days.

Corn grain is always low in nitrate. Under normal growing conditions, the corn plant will be nearly 50% grain at harvest time. Thus, nitrate toxicity threat comes only when conditions inhibit normal maturity of the plant.

NITRATE AND THE ANIMAL. Normally, the plant uses the nitrogen in nitrate to make protein. The same conversion of the nitrate to ammonia to protein can be made by rumen bacteria in the first stomach compartment of cattle and sheep.

Rations high in available energy favor the use of nitrate by the bacteria and decrease chances of a nitrate toxicity.

Nitrate toxicities occur when high nitrate levels in the feed overwhelm the system. A simplified scheme for the conversion of nitrate in the rumen of cattle or sheep is as follows:

Nitrate (NO_3) $\longrightarrow$ Nitrite (NO_2) $\longrightarrow$ Hydroxylamine (NH_2OH) $\longrightarrow$ Ammonia (NH_3) $\longrightarrow$ Amino Acids $\longrightarrow$ Protein

A nitrate toxicity occurs when nitrate converts to nitrite faster than nitrite converts to ammonia.

When this happens, nitrite (NO_2) accumulates and is absorbed into the blood stream. There it reacts with the oxygen-carrying hemoglobin (bright red) to produce reduced hemoglobin (chocolate color) which cannot carry oxygen.

The animal literally suffocates when too much hemoglobin is affected.

ENSILING AND NITRATE. We have studied corn forage fertilized with up to 800 lb N/A. Ensiling corn forage reduced nitrate content about one-third, shown in **Table 1.**

Table 1. Effect of ensiling on nitrate content of corn silage.

	Nitrogen Lb/A		
	0	200	800
GREEN FORAGE			
Nitrate (ppm)[1]	602	2319	4438
SILAGE			
Nitrate (ppm)[1]	380	1468	2861
Decrease with ensiling (%)	37	41	36
pH	3.9	3.8	3.8

[1]Nitrate values on dry basis. To convert the values from ppm to percent, move decimal point four places to left, i.e. 602 ppm is .06 percent.

The nitrate declined further with the addition of 20 lb limestone per ton of silage. More than 20 lb nitrogen per ton (30 and 40 lb) reduced the nitrate even more. But the higher limestone affected silage fermentation and quality adversely. So we do not encourage the addition of limestone when ensiling corn forage.

ADAPTATION OF ANIMALS TO NITRATE. In feeding ruminant animals, it pays not to make drastic changes in feed without allowing sufficient time for the rumen bacteria to adjust to the new feed.

Making a very rapid change from a poor forage to green corn, corn silage, or high grain may throw the animal off-feed. The same feed change made gradually over one to two weeks should cause no problem.

Adaptation also occurs when animals are changed slowly to high nitrate feeds.

When we fed green corn of 2.29% nitrate to unadapted rumen—fistulated steers—nitrate in the rumen fluid increased in one to 1.5 hours after feeding.

Nitrate levels were lower succeeding days and did not increase after feeding when experimental forages were fed to adapted animals. At no time in our studies did we encounter problems associated with nitrate.

Our data indicates that the nitrate problem can be prevented by placing animals on feed slowly to give the rumen bacteria time to adapt to the nitrate.

NITRATE, SUDANGRASS, AND SHEEP. Corn forage is a high energy forage favoring use of nitrate in the rumen. In contrast, sudangrass is a low energy feed. Consequently, sudangrass fertilized with O, 200 and 800 lb N/A was fed free choice to sheep.

The crude protein and nitrate in the sudangrass is shown in **Table 2.** At the highest nitrogen rate, the sudangrass feed contained 2.20% nitrate. The animals showed no harmful effects from these nitrate levels.

Table 2. Effect of nitrogen fertilization on protein and nitrate in sudangrass.

	Chemical Comp. (Dry Basis)	
Nitrogen Lb/A	Crude Protein	Nitrate
	%	
First Growth		
0	14.2	0.70[1]
200	17.2	1.25
800	19.3	1.73
Regrowth		
0	21.0	0.69
200	22.4	1.53
800	24.1	2.20

[1]To convert percent to ppm move decimal point four places to right, i.e. 0.70 percent is 7000 ppm.

NITRATE IN CORN GRAIN. Nitrogen fertilization increased crude protein content of corn grain from 8.69 to 9.41 percent, shown in **Table 3.** Nitrate content varied from 35 to 64 ppm, very low compared to the forage.

Table 3. Nitrogen fertilization and corn grain.

Nitrogen Lb/A	Crude Protein[a]	Nitrate[a]
	(%)	(ppm)
0	8.69	48
200	8.53	35
800	9.41	64

[a] Values on dry basis.

Corn grain normally contains almost no nitrate and is not considered to be a problem. If present, most of the nitrate will be found in the stalk. So nitrate toxicity risk is greatest when animals are consuming cornstalks.

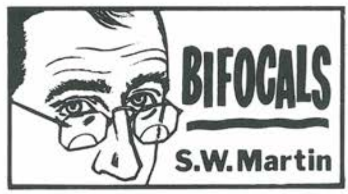
NITRATE AND SILO GAS. Ensiling high nitrate forage can be dangerous when poisonous nitrogen gases form during filling or shortly thereafter. Frequently the reddish gas can be seen coming from the silo. This gas is highly toxic to man and animals.

Danger exists from ensiling through the week after. So, during filling, or shortly thereafter, don't enter a silo without first running the blower for a few minutes or ventilating it some other way.

IN CONCLUSION, it appears nitrate toxicity is often blamed when something else may be the cause—such as throwing the animal off-feed or failing to balance the ration. Under normal feeding situations, it appears a feed must contain over 2.0 percent nitrate to cause nitrate toxicity. Very few forages, particularly corn, contain enough nitrate to approach toxic levels.

When there is a doubt, there are some steps to reduce the likelihood of a problem:

1. **Make the feed change to a questionable feed over a period of one to two weeks to adapt the rumen bacteria. Use this procedure anytime drastic changes are made in diets of cattle and sheep.**
2. **Use high energy feeds, such as corn grain, along with the high nitrate feeds. High energy feeds help the rumen bacteria use the nitrate.**
3. **Ensile the corn plant to help reduce the nitrate. Adding 20 lb limestone per ton corn forage going into the silo reduces nitrate further. But limestone should be added very carefully because it tends to raise the pH of the silage which will produce a poor quality silage, if excessive.**
4. **Dilute high nitrate feeds with low nitrate feeds, such as grain and legume hay, to lower the percentage of nitrate in the daily ration.**
5. **Corn stalks from drought-stressed corn may be high in nitrate. Nitrates tend to accumulate in the stalk, so use more care when feeding stalks.**
6. **Balance the ration.**



THIS MAGAZINE has been on the American scene since 1923. It has been an Institute magazine since 1935.

We wonder if there are any readers still alive who have received it since the 1920's, the 30's, or even the 40's.

If so, drop us a card. This would be a nice way to welcome our new editor, Bill Agerton.

Just address the card WELCOME to our new address on the back cover. Or mail the form on page 12, which seeks reader advice on how to improve our journal.

Editor Agerton comes at a time when an expert recently said, "I can't put my finger on it. But the overall style of Better Crops magazine has an image that doesn't look modern when compared to first class industry publications."

Maybe the word he was seeking was "old-fashioned."

A few issues from now that

expert may see a different image, because Agerton brings fresh, modern ideas to one of the longest-lived trade journals in American industry.

This freshness is born from solid, down-to-earth experience that seems tailored to this kind of journal:

• Farm-raised near Ariton, Alabama.

• Bachelor of Science and Master of Education from Auburn University.

• Area Field Representative for the Alabama Farm Bureau Federation.

• Associate Editor and Editor of the Alabama Farm Bureau News.

• Publications Editor, University of Georgia Agricultural Extension Service.

• In Visual Aids, winner of the Alabama County Agents Association Slide Competition.

• In Publications, winner of the Gold Medal and Silver Medal Awards for the Alabama Farm Bureau News.

• Active in Agricultural Communicators, National Marketing Association, National Association of County Agents, and Kappa Delta Pi.

• Past President of two Civitan Clubs in Alabama.

• Past President, Montgomery (Ala.) Association of Business Communicators.

The most interesting credential he brings is the strong drive that led him into communications, not through a journalism school or writing course, but a natural gift for it.

And like the sports writer in the newspaper world, he started working with words and pictures in one of the best areas possible to develop a crisp, interesting style of communications—in 4-H work developing into a photo journalist first.

Pictures must have words to tell their full story. And the human interest material in 4-H work was a natural training ground for Bill Agerton's way with words and visuals.

As an editor of Alabama's Farm Bureau News, he experienced something of newspapering, because the tabloid he edited was loaded with news on farm people, their leaders, and the events they cause to happen.

Then, as Georgia's Publications Editor for Extension, he mixed many parts of the communications game — ranging from publications on 4-H activities to agronomic reports and different types of Farm Day materials.

The 39-year-old editor now enters a new phase of a life that has been very active in his profession, his community, and his church.

The opportunities for creative work with Institute publications and visuals are very great. The work can use good advice. So, he and we would welcome your counsel. You can give it on page 12.

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