Better Crops WITH PLANT FOOD

Number 4—1968 25 Cents

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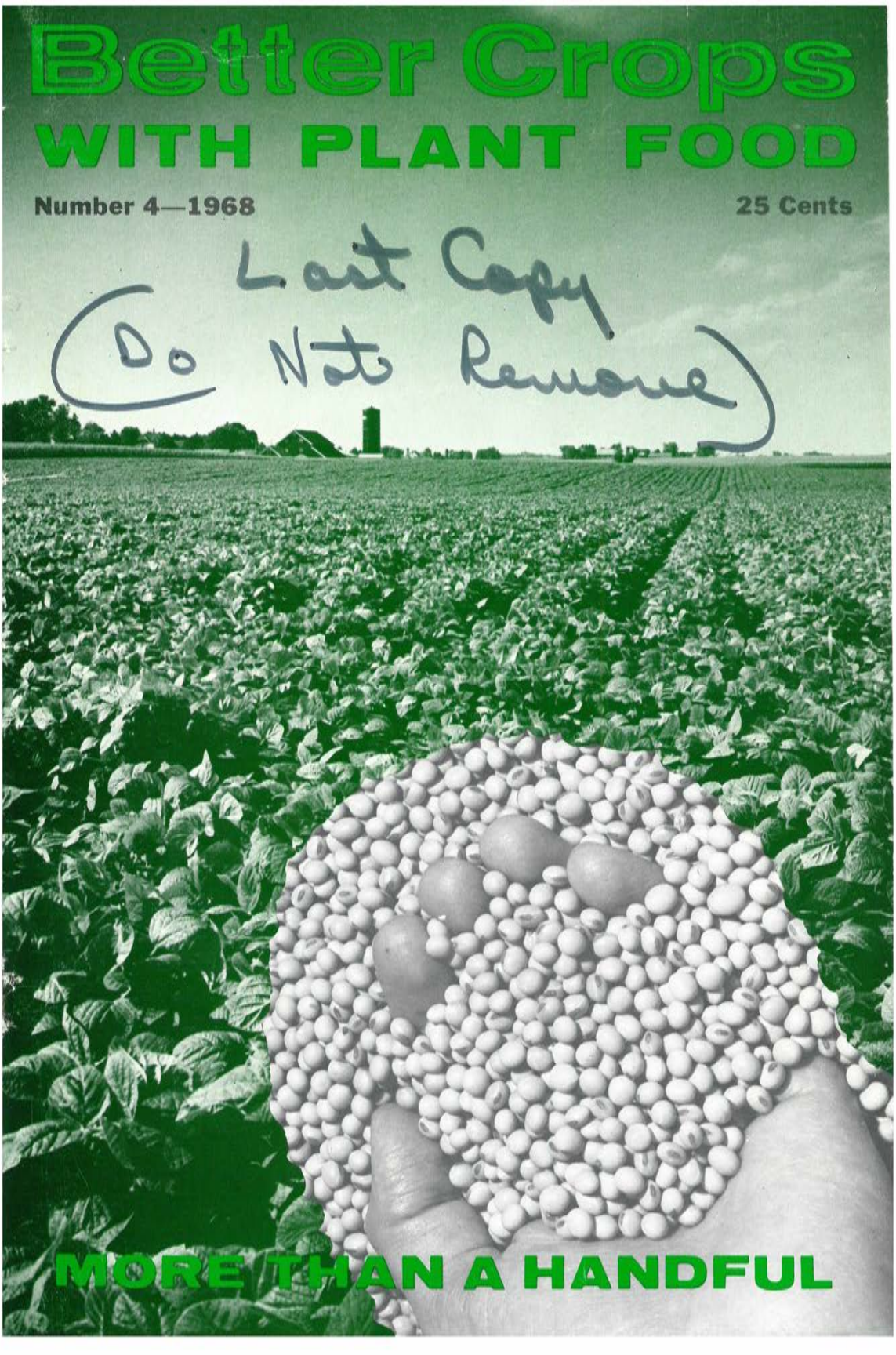

MORE THAN A HANDFUL

You bet...

. . . those soybeans on the cover are **MORE THAN A HANDFUL.**

- **They are a fieldful of quantity.**
- **They are a fieldful of quality.**

Such a fieldful comes from hard work and know-how! This efficiency demands constant vigilance against the SEVEN SINS of SOYBEAN PRODUCTION, described by champion soybean grower, James Jacks, in the **Delta Farm Press.** Jacks, a Mississippi grower who wins soybean contests with 90-bu/A averages, cited these 7 Deadly Sins:

1—The Sin of Poor Weed Control: Probably No. 1 reason for 31-bushel average in a top state, 21 to 24-bu. average in the South. Easily eliminated by right use of present chemicals and mechanical equipment.
2—The Sin of Low pH and Low Fertility: A pH below 6.0 in topsoil and 5.5 in subsoil (7 to 12 in.) will not get high yields. Soybeans WILL RESPOND to fertile soil just as cotton and corn will. Pick up 5 to 8 bushels MORE per acre by building up soils low-to-medium in P&K to at least medium plus.
3—The Sin of Moisture Mismanagement: Most southern states average enough rain to get at least 30 bu./A. But too many fail to store it up in winter months. In spring, we plow away what we do have—and let weeds drink the rest.
4—The Sin of Unwise Planting and Variety Selection: Insure clean seedbed, in good tilth, not overworked. Select variety for land type, for its ability to resist diseases and compete with weeds. Some varieties do better on clay than on sand. Wise selection can mean 3 to 10 MORE bushels per acre to you.
5—The Sin of Poor Harvest Practices: Too many 40-bushel soybean yields only weigh out 30 to 32 all because of harvest loss. A skilled operator with well adjusted combine should not lose over 2 bushels per acre.
6—The Sin of Unskilled Management and Labor: Some people farming soybeans do not have management skill and many are not willing to learn. Management aids are readily available from many sources: Extension Services, Experiment Stations, farm suppliers of all kinds, even friends and neighbors who have succeeded at it. Be open minded. Be daring. Be dedicated. Develop as much business sense as common sense.
7—The Sin of Poor Marketing: The only marketing know-how many soybean producers possess is the direction to the local elevator. Every producer should know what quality is, how the marketing system works, what storage is worth, how to use futures market, and how to bargain with buyers.

James Jacks speaks from success, not theory—90-bushels-per-acre success in regional contests. Good equipment, skilled labor, fertile soil, and adequate capital are essential, he explains. But it's how you put these together that counts at the bank. Management is the key!

Check the soybean fertility tools on the inside back cover. They may put you or your soybean growers on the road to James Jacks' record. They are practical, up-to-date tips to more beans per acre.

Better Crops WITH PLANT FOOD

The Whole Truth—Not Selected Truth

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CONTENTS

HIGH Potash Capacity of Corn Hybrids To

L. M. JOSEPHSON
W. L. PARKS
CHARLES FREEMAN

CLOSER SPACING of plants and greater fertilization are essential for top corn yields.

Under these conditions plants grow taller and are less sturdy, resulting in more breakage. Part of the breakage under high yield conditions is due to premature dying of the stalks, particularly when inadequate potassium is available.

Tennessee experiments show that hybrids can be developed which use fertility efficiently, will stand up, and produce high yields.

Experiments initiated on Hartsells loam at Crossville, Tennessee in 1966 involved four inbreds, the six possible single crosses from them, and the three permutations of the hybrids Dixie 29 and Tenn. 604.

The test area was uniformly low in potash and received two tons of lime, 80 lb. P_2O_5, 150 lb. N, and 20 lb. zinc sulphate per acre. The K_2O treatments were 0, 40, and 120 lb. per acre applied at KCl.

Table 1 shows how potassium fertilizer affected yields of the inbreds and single crosses of Dixie 29 during a 2-year period. Similar results were obtained for Tenn. 604.

Responses from potassium additions

LOW Potash

Absorb & Use Potassium

UNIVERSITY
OF
TENNESSEE

differed strikingly. Inbred T111 increased only 7 bushels per acre from 120 lb. K_2O, while T115 increased 33 bushels. T111 had the highest yield without added potash and T115 and T101 had the lowest.

DIFFERENCES IN YIELDS at low K levels are probably related to the extent and activity of the root systems and to how efficiently the inbreds use potassium. T111 had a larger root system than the

Table 1. Effect of Potassium Fertilizer on Corn Yields (2 yr. avg.)

	Potassium Applied, lbs. K_2O/A		
Corn type	0	40	120
	bu/A	bu/A	bu/A
Inbreds			
T101	3.4	21.4(529)	33.4(882)
T105	5.1	24.6(382)	26.2(414)
T111	10.0	16.6(66)	17.0(70)
T115	2.6	26.1(904)	35.6(1269)
Single crosses			
T101 × T105	61.4	99.2(62)	117.0(91)
T101 × T111	69.0	103.1(49)	114.4(66)
T101 × T115	47.4	91.6(93)	115.9(144)
T105 × T111	73.4	98.0(34)	100.2(36)
T105 × T115	36.5	85.1(133)	97.4(167)
T111 × T115	49.0	102.6(109)	119.6(144)

Figures in parentheses are the percentage increases over O potash.

other inbreds. **But in Table 2, plant analysis data showed no great differences in potassium content of ear-leaf tissue when the plants were grown at low potassium levels.**

Table 2. Percent Potassium in Corn Ear Leaf Tissue (2-yr. avg.).

	Potassium Applied, lb. K_2O/A		
Corn Type	0	40	120
Inbreds			
T101	.60	1.00	1.62
T105	.50	1.25	1.69
T111	.58	1.11	1.54
T115	.52	.86	1.43
Single Crosses			
T101 × T105	.57	.89	1.81
T101 × T111	.68	1.14	1.80
T101 × T115	.51	.90	1.68
T105 × T111	.71	.98	1.78
T105 × T115	.50	1.11	1.74
T111 × T115	.53	1.19	1.65

Response of the inbreds is also reflected in the yields of the single crosses. **This is more vividly shown in Figure 1.** The response of T115 over T111, both as inbred and in crosses, was very important. Correlation of the response of the inbreds with their response in single crosses was significant. Correlation of the yields of the inbreds with their yields in single crosses was also significant on the plots with no added potash.

In Table 2, leaf analyses data show that, at the two lower potassium levels, the hybrids having the highest potassium content produced the highest yields. After 120 pounds per acre K_2O was added, little relationship existed between potassium content and yield.

The three double cross permutations did not differ significantly in yield. But there was close agreement between their actual yields and the yields expected from the response of the single crosses.

'K REDUCES LODGING. Stalks that remain green through maturity generally do not lodge unless they have been punctured by an insect or have stalk rot. All hybrids, except T111xT115, showed a sharp decrease in dead stalks at harvest with added

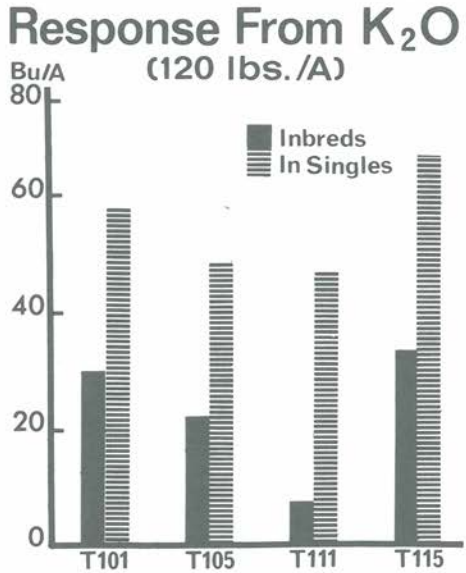


Figure 1. Response of inbreds per se and in single crosses from additions of 120 pounds K_2O per acre.

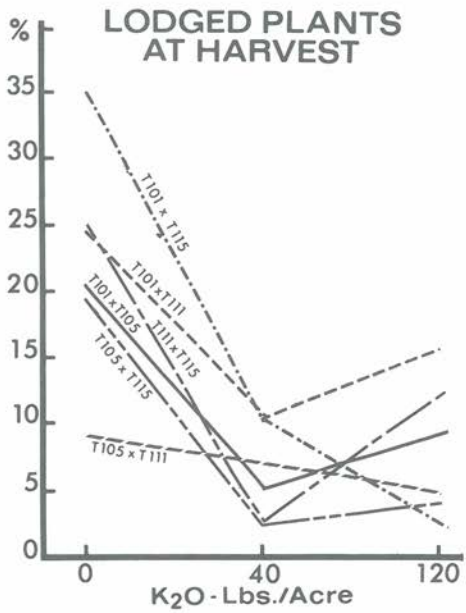


Figure 2. Percentage lodged plants at harvest from additions of 0, 40, and 120 pounds K_2O per acre.

K_2O. The added potash also slowed rate of stalk senescence (aging).

Figure 2 shows how the number of lodged plants decreased sharply when 40 lb. K_2O per acre was added, except with T105xT111. With added K_2O, this hybrid showed little response in yield and also little reduction in dead stalks.

Some hybrids had increased lodging when 120 pounds K_2O was added. Apparently maximum yields were being reached at this level.

Similar reductions in lodging occurred in the inbreds and double crosses with added K_2O.

Major Conclusions

1. Inbreds differ in their ability to absorb potassium on low soil potassium levels and to respond to added amounts of K_2O. They transmit this ability to their hybrids.

2. Inbreds and hybrids that respond poorly to added K_2O generally have the highest yields on low potassium soils.

3. Breeders can use these findings in selecting hybrids that will produce well under different fertility levels.

4. The data also indicate some hybrids will respond to large amounts of potassium while others will not. Likewise, some hybrids may perform better than others on low-to-moderate fertility levels.

5. Maintaining adequate potassium level in the soil will greatly reduce lodging in many corn hybrids.

THE END

AVOID SO-SO SOYBEANS

GROW GO-GO SOYBEANS

SPREAD THE TOOLS

SEE INSIDE BACK COVER

Encourage Young Research Workers

The International Potash Institute (Berne) has organized a third competition for young research workers in which prizes will be awarded for papers on the chemical, biological or physiological role of potassium in the soil, in the vegetable realm or in the animal organism, including the field of human nutrition.

- **A sum of 4000 Swiss Francs will be awarded as prizes.**
- Only researchers are eligible who have not passed the age of forty on completion of their papers.
- **Both published and unpublished papers may be entered provided they were completed in 1966, 1967 or 1968.**
- The papers must be written in, or translated into, one of the four official languages of the Institute viz. English, German, French or Spanish. In the case of a very lengthy study in another language, this may be submitted if accompanied by a summary in one of the four above-mentioned languages sufficiently detailed to enable the paper as a whole to be assessed on its merits. The papers must be submitted to the Institute neatly typed in six copies.
- **The texts of papers complying with the above conditions must reach the International Potassium Institute, 30, Zieglerstrasse, Berne (Switzerland) not later than February 28, 1969.**
- The entries will be examined by a committee of three members of the Scientific Council of the International Potassium Institute.
- **Entrants will be notified of the results of the competition by November 30, 1969 at the latest, on which date manuscripts not awarded a prize will be returned to their authors.**

Investigation table in center, demonstration table in rear, and 20 study stalls give students good work environment.

Each stall features taped lessons illustrated by projected slides. This student takes notes in his workbook.

Soil Science TEACHING Comes

HENRY D. FOTH MICHIGAN STATE UNIVERSITY

MICHIGAN STATE UNIVERSITY has developed a new approach for teaching the introductory soil science course. The five-credit course has only two lectures a week. The major part is taught in an unscheduled multi-media independent study laboratory, created to improve and individualize this instruction. Investigations are designed to give the student more experience in discovered knowledge and, hopefully, to shift his motivation for learning away from external rewards—grades, credits, etc.—and toward intrinsic rewards of understanding.

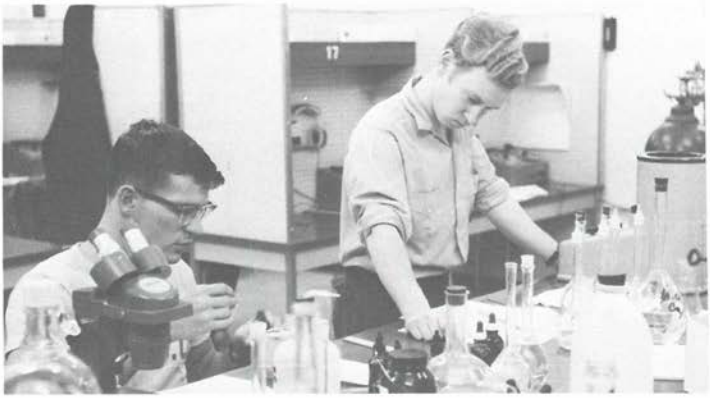
Fourteen study projects are now available, with about three more being planned for the future. Each project provides about two hours of "self-instruction." An instructor is present in the laboratory to answer questions or discuss the material, when needed.

A workbook gives the student all learning tasks in chronological order. To secure content material, explanations for conducting investigations, and the significance of the material, he uses a tape-recorded guide illustrated by many color slides.

The lab features a demonstration table where the student can exhibit soil profiles, samples of soil structure, photographs, drainage tile, tensiometers, etc. Rarely do more than one or two students want to use the demonstration table at the same time. This spacing enables one or two pieces of most scientific instruments to serve the needs of a large number of students. The students conduct project investigations on a central lab bench.

Students like the non-scheduled lab hours and the opportunity to go over difficult material until they have mastered it. This learning approach makes students assume more responsibility for learning, makes them participate more actively in the learning process than they usually do in a largely lecture course. They learn more by practicing—by observing and investigating. They tend to learn less by believing what the teacher says, the more

This student studies minerals and results of weathering. Observing the subject by microscope, he is tutored by tape.



At the lab bench, students probe cation exchange and flocculation facts, later used to answer workbook questions.

ALIVE!

traditional approach. We believe the student will remember better under the practicing method.

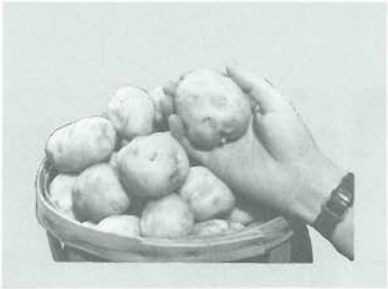
During one term, 61 percent of the students thought this approach would cause them to remember the material longer. Only 10 percent disagreed and 29 percent were uncertain. We also believe that this kind of learning will enable the student to use the information more readily in the future.

This program was developed in recognition of the truth many years ago by Comenius: "The more the teacher teaches, the less the student learns." Each person learns by himself and must actively participate. Setting up such contigencies for learning has also, I believe, made Soil Science a "living" subject for the student.

Persons desiring more details about this program should write for Project Report No. 204, Educational Development Program, Michigan State University, East Lansing, Michigan 48823.

THE END

The demonstration table gives 24 ft. exhibit space. This student notes 3 soil profiles with different horizons.



Potash Boosts Vegetable Yields

POTATOES	33%
TOMATOES	30%
PEPPERS	21%
S. CORN	9%
LETTUCE	65%

ROY FLANNERY
RUTGERS STATE UNIVERSITY

VEGETABLE GROWERS seeking more yield out of each costly acre might look at what New Jersey scientists did to boost total vegetable yields more than 15 tons per acre on 5 acres.

In a 3-year trial on Freehold sandy loam soil at Adelphia, the yields of five vegetable crops rose sharply after their potash diet was increased from 50 lbs. to 200 lb. potash (K_2O) per acre. Table 1 tells the potash story.

Table 2 features the full fertility treatments and cultural practices the five vegetables received.

LEAF TESTS showed K content, Table 3 shows how the K content of leaves rose with increasing potash application, while magnesium and calcium content declined. Potassium levels affected magnesium content more than they did calcium content.

Potassium is recognized as a health-building element. How much gets into plant tissue is important to crop quality. Note the different levels in the leaf tissue of each crop under the various potassium treatments in Table 3.

SOIL TESTS showed K depletion in Figure 1. When only 50 lbs. K_2O per acre was applied, the soil's potash level declined steadily over the 3-year trial. When 200 lb. K_2O per acre was applied, available potash in the soil was well maintained. In fact, it gradually increased.

The soil test level shot up tremendously under the 400 lb. K_2O treatment. This indicates two things: (1) This treatment exceeds the growing crop's need, (2) Not much potash is being lost to leaching.

Both the yields and the soil tests indicate this soil needs around 200 lb. K_2O per acre yearly to grow good yields and to maintain the soil's potash supply.

WHEN POTASH treatment went from 50 lb. to 200 lb. K_2O per acre. . .

. . . **No. 1 Potato** yields increased $\frac{1}{3}$ per acre . . . a little more at 400 lb. K_2O rate. No. 2 grade increased just slightly. Specific gravity held about the same, but

Table 1. Potash boosts Vegetable Yields (total No. 1 and No. 2 Grade).

K_2O lbs/A	Potatoes cwt/A 3 yr. ave.	Tomatoes Tons/A 3 yr. ave.	Peppers lbs/A 3 yr. ave.	Sweet Corn lbs/A 2 yr. ave.	Lettuce lbs/A 1 yr.
50	252	29.3	15,990	12,560	13,150
200	331	36.2	18,970	13,630	17,110
400	337	37.7	18,320	13,850	15,540

Table 2. Complete Cultural Practices.

	Potatoes	Tomatoes	Peppers	Sweet Corn	Lettuce
Years in Exp.	3	3	3	2	1
Variety	Katahdin	Heinz 1350 & Campbell's 17	Yolo L and Yolo Wonder	Exper. 222 & Gold Cup	Fulton Iceburg
Planting Date	April 12-26	May 10-16	May 14-29	May 3-5	April 9
Plant Spacing	3′×10″	3′×2′	3′×2′	3′×10′	2′×1¼′
Plant Population	17,424	7,260	7,260	17,424	17,424
No. Harvests	1	4	7—8	2	2

pH All plots limed to pH 6.5
N* 125 lbs/A NH_4NO_3 uniform application each year (N adjusted on KNO_3 plots)
P_2O_5* None applied—tested very high prior to experiment
K_2O* 50—200—400 lbs/A applied as variable treatment
Mg None applied—tested high prior to experiment
Ca Plots tested 930 lbs. per acre (medium) prior to liming.
Irrigation All plots were irrigated as needed.

*Sweet corn received additional 250 lbs. 10-10-10 banded in row at planting.
Potatoes received 500 lbs. of 0-20-0 banded at planting.

Table 3. Leaf Tissue Analysis (Percent).

K_2O lbs/A	Potatoes			Tomatoes			Peppers			Sweet Corn			Lettuce		
	K	Mg	Ca	K	Mg	Ca	K	Mg	Ca	K	Mg	Ca	K	Mg	Ca
50	1.72	1.45	1.67	2.87	1.12	3.30	3.52	1.54	2.20	2.01	0.39	0.44	3.01	0.52	0.70
200	3.01	1.05	1.49	3.87	0.94	3.10	4.98	1.11	1.96	2.37	0.28	0.40	4.12	0.44	0.63
400	3.88	0.88	1.26	4.28	0.84	2.73	5.91	0.94	1.83	2.63	0.23	0.39	4.07	0.37	0.68

TABLE 4

	FROM AROUND THE STATE		FROM THIS EXPERIMENT	
	Ave. State Yield 1965-1967	Maximum Yields in State	Top Treatment Average	Top Treatment one year
Potatoes (cwt.)	232	400	337 (400# K_2O)	371 (400# K_2O)
Tomatoes (tons)	15.9	37.0	37.7 (400# K_2O)	42.9 (400# K_2O)
Peppers (lbs.)	6,300	20,000	18,970 (200# K_2O)	21,528 (200# K_2O)
Sweet Corn (lbs.)	7,300	15,000	13,850 (400# K_2O)	15,216 (200# K_2O)
Lettuce (lbs.)	17,000	18,500	17,110 (200# K_2O)	17,110 (200# K_2O)

Soil Test Levels After Cropping

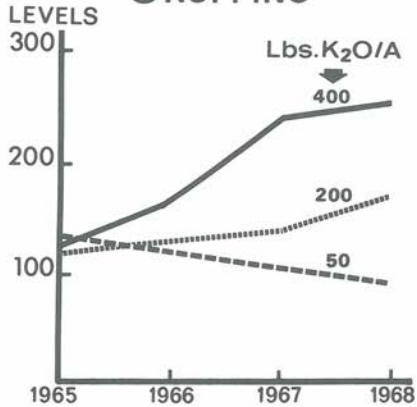


FIGURE 1

Table 5. Selling Price New Jersey Vegetables Average (1965-1967)

Crop	Season Ave. Price
Tomatoes	$38.20/ton
Peppers	7.90/cwt.
Potatoes	2.24/cwt.
Sweet Corn	3.90/cwt
Lettuce	7.90/cwt.

TOTAL VEGETABLE YIELDS

(3-Yr. Avg.)

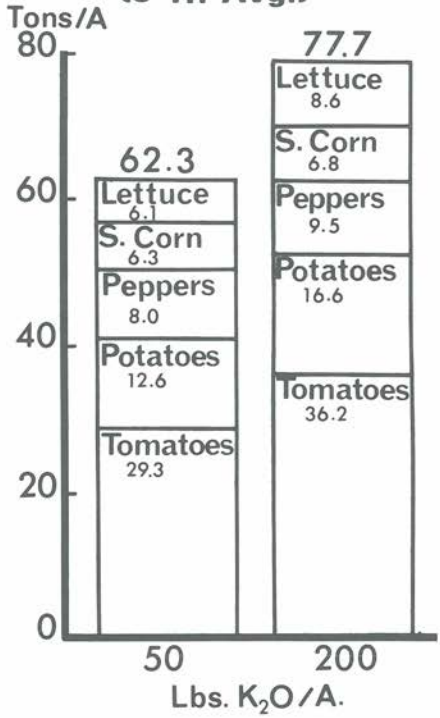


FIGURE 2

dropped slightly under 400 lb. K_2O rate.

. . . **No. 1 Tomato** yields increased 30% per acre . . . a little more at 400 lb. K_2O rates. Did not affect No. 2 grade. Ca levels in leaves tested much higher than in other crops.

. . . **No. 1 Pepper** yields increased nearly 21% per acre . . . declined two out of three years at 400 lb. rates. No. 2 peppers increased a little. Levels of K and Mg in the leaves tested higher than with other crops.

. . . **No. 1 Sweet Corn** yields increased nearly 9% and grade 1 ears nearly 4% per acre . . . a little more at 400 lb. rates. Levels of K, Mg, and Ca in the leaves tested lower than in other crops.

. . . **No. 1 Lettuce** yields increased 65% per acre in the one year the crop was grown . . . but declined at 400 lb. rate. No. 2 grade declined at 200 and 400 lb. K_2O rates.

CAN TOP vegetable yields be reached in New Jersey? Table 4 compares current New Jersey yields with this experiment. While the state was averaging 15.9 tons of tomatoes and hitting a top yield of 37 tons per acre, this 3-year experiment was averaging 37.7 tons per acre and hitting a top yield of 42.9 tons one year.

Vegetables are a high value crop. Farmers growing them in New Jersey have big investments on small acreages. They must get the best yield they can. Figure 2 shows the difference between 50 lb. and 200 lb. K_2O per acre on five acres of five different vegetable crops. Shifting only his fertilizer practice to 200 lb. K_2O per acre the grower would have increased his yield 15.4 tons per year on five acres.

This extra 15.4 tons of vegetables would have added more than $1100 to his gross return from the five acres. Can vegetable growers afford to scrimp on their fertilizer—in this case potassium—when it **COSTS THEM PROFITS?**

THE END

Watch Needs of IRRIGATED Turf

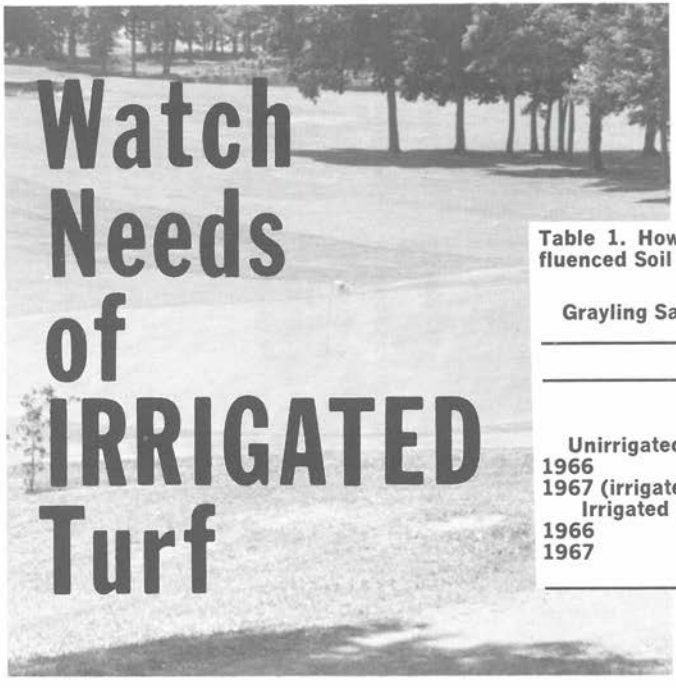


Table 1. How Four Years of Irrigation Influenced Soil Tests Under Merion Kentucky Bluegrass.

Grayling Sand, Traverse City, Michigan

	pH	K	Ca	Mg
		lbs. per acre		
Unirrigated plots				
1966	6.4	256	1629	59
1967 (irrigated)	6.4	102	1194	98
Irrigated plots				
1966	7.2	87	2394	171
1967	7.2	93	1559	148

P. E. RIEKE
MICHIGAN STATE UNIVERSITY

WHAT FERTILIZATION program is best for turfgrasses under intensive management? Many factors should be carefully considered.

For potassium fertilization, consider soil texture, the amount and quality of irrigation water, and a proper balance of potassium to other nutrients.

Turf areas, especially golf greens, are frequently established on sandy soils because of their relative resistance to compaction.

Consider what happened to Merion Kentucky bluegrass plots established on Grayling sand at Traverse City, Michigan, in 1963. Two pounds of K_2O were applied per 1000 square feet each spring. One set of plots was irrigated, one area unirrigated. Soil samples were taken in October, 1966 and 1967. **Table 1 shows what irrigation did to potassium level.**

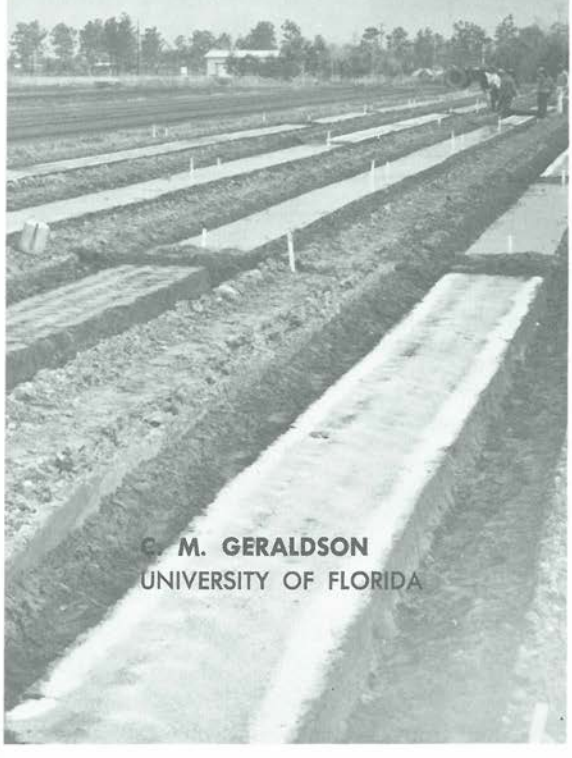
In 1966, irrigation apparently leached potassium from this sandy soil, while calcium and magnesium accumulated from the irrigation water. At the same time, the pH increased from 6.4 to 7.2. A test of 87 lb. K per acre would be considered medium for turfgrass, while 256 would be a high test.

In 1967 the area previously unirrigated was watered regularly. Irrigation caused potassium to leach, especially when compared to the previously unirrigated area. Note how the potassium test dropped from 256 to 102 lb. per acre. In the meantime, the potassium test for the **irrigated area remained the same.**

In sandy soil that is intensively irrigated, you might consider at least two applications of potash per year. Base application rates on soil test, soil texture, and the rate and quality of irrigation water used.

THE END

Building Flat Tops FOR *TOP-YIELD ACTION!*



C. M. GERALDSON
UNIVERSITY OF FLORIDA

Precision Crop FEEDING

THROUGH NUTRIENT CONCENTRATION AND BALANCE

AVERAGE TOMATO YIELDS have climbed 40% in Florida in the past decade. Experimental plots now consistently yield 45 tons or more per acre—1500 to 2000 bushels per acre!

And commercial yields sometimes reach the same high levels.

What's behind such increased yields? One factor is a program to provide the crop with the right balance and intensity of nutrients when and where it needs them.

We might call it precision crop feeding. Most Florida growers produce tomatoes in one of three ways: (1) on ground, (2) on stake, (3) on trellis. When managed right, the trellis method has gained the huge 40 to 60-ton yields. The other two cultures have averaged 3 to 25 tons per acre.

Trellis production costs more, but also pays more profit per acre. And top profit per acre is what the grower is after.

Precision nutrition not only builds yields, but also improves tomato quality. Table 1 shows how carefully controlled nutrition joined right water control, plant population, variety, and cultural timing to build the huge yields of quality fruit—1500+ bushels per acre.

CURRENT RESEARCH. For several crop seasons now, Florida research has probed three areas vital to crop producers:

How **different** nutrient quantities, sources, and placement methods affect the concentration and balance of soil nutrients.

Which **changes** in these nutrient concentrations and balances improve crop yields and quality.

How **plastic mulch** helps control nutrient movement in Florida's sandy soils.

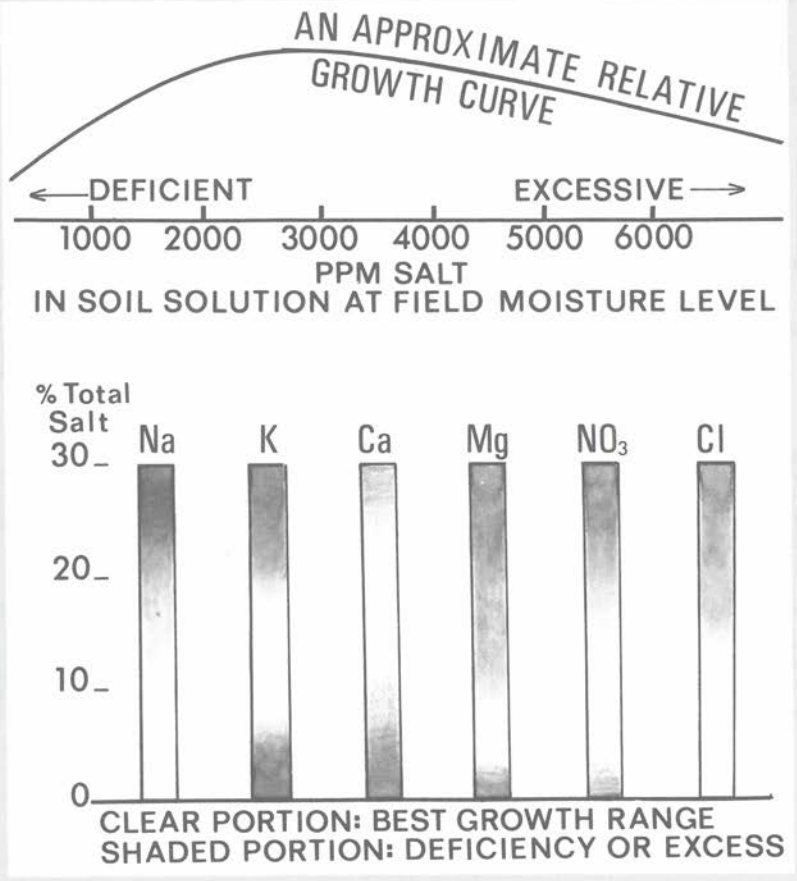


Figure 1—These Ranges of Nutrient Concentration and Balances Produced Best Yields

To determine nutrient intensity and balance, we measure total salts and ratios of specific nutrients in the soil saturation extract. We then calculate these figures

Table 1. Comparable yields and average fruit size of tomatoes for eight crop seasons (Experimental plots).

	Spring		Fall	
	Harvested 5/1—6/10		Harvested 11/1—1/10	
	bushel/acre	lbs/fruit	bushels/acre	lbs/fruit
1964	1550	.453	1577	.384
1965	1532	.468	1659	.425
1966**	1243	.411	1639	.429
1967**	1295	.471	1731*	.458

*All comparisons are of the same variety (Floradel). In the fall of 1967 a new variety in the same experiment produced over 2000 bushel per acre averaging over 0.5 lb/fruit.
**Hurricane Alma damaged the 1966 Spring Crop during the later stages of production. In the Spring of 1967, Phoma caused damage resulting in reduced production.

Table 2. Ionic concentration (ppm) and balances (%) in the soil solution from fractionated portions of the soil used in growing trellised tomatoes.

Experimental plots—Spring crop 1966

		18″ water table				12″ water table			
		Salt	K	Ca	No_3	Salt	K	Ca	NO_3
Fert. band	2″	16000	24.4	6.2	7.2	5450	5.4	7.4	0.3
	2—4	3760	2.7	10.9	5.8	2280	2.3	11.5	0.6
	4—8	1200	3.2	12.4	0.3	1200	1.3	12.3	0.4
between	2″	11800	15.4	6.4	7.9	5750	3.8	9.3	0.2
	2—4	5200	2.8	11.5	1.1	4300	5.8	11.5	0.3
	4—8	2420	3.2	11.2	0.9	1420	1.8	12.7	0.6
		Yield—1639 bu/A				Yield—1269 bu/A			

Fertilizer:
Covered with plastic mulch after application of 360 lbs N—500 lbs K_2O/acre; 90-95% banded on the bed surface, 12 inches to either side of the plant row, the remainder broadcast on the surface between the bands. 500 lbs superphosphate + 20 lbs fritted trace elements mixed in the bed.

Water table:
Maintained at 12 or 18 inches below the bed surface by means of seep ditch irrigation.

Sampling:
Fractioned to the indicated depth in the fertilizer band and half way between the plant row and fertilizer band. Samples were obtained about the middle of the harvest season (5/26/66).

for specific field moisture level which depends largely on water table maintained in Florida soils.

Figure 1 shows the range of nutrient concentration and balances that produced best yields. At field capacity moisture, unfertilized soil areas may normally contain 100 to 500 ppm salt while the area around the fertilizer band may range from 10000 to 50000 ppm.

Water moving through the soil tends to move the salt. And in the sandy podsols of Florida, seepage irrigation and plant transpiration moves the salt toward the surface. Banding fertilizer on the surface and covering it with plastic mulch tends to maintain higher concentrations near the surface.

Tables 2 and 3 illustrate this point. These fractional soil samples show how much the soil solution will vary from different parts of the soil bed. In contrast, Figure 1 is based on 0-6 to 0-8 inch borings across the bed representing an average of the bed profile. Such soil differences cause one to vary interpretations and correlations with sampling procedures.

Table 2 shows how a combination of deficiencies can drag down crop yields. Why did the 12-inch bed average only 1269 bu/A—or 370 bu/A LESS than the 18-inch bed? Too little K and NO_3-nitrogen percentages, as shown by Figure 1 values. When bed tops and fertilizer are 15 to 18 inches above the water table, nutrient loss is minimum.

Table 3 shows how a combination of excesses can drag down crop yields and quality. In this case, too much salt (especially sodium and chloride) accumulated in the entire profile. It led to calcium hunger which seemed to open the door to blossom-end rot in Area A.

Table 3. Ionic concentration (ppm) and balances (%) in the soil solution from fractionated portions of the soil used in growing trellised tomatoes.

Commercial Field—Spring 1967

(A)*		Salt	K	Ca	Na**	NO_3	Cl**
Fert. band	2″	33000	28.4	8.7	4.7	12.9	7.4
	2—4	11200	17.3	5.0	17.9	4.5	23.2
	4—8	5700	10.1	3.9	24.2	2.1	33.9
between	2″	18000	20.4	8.8	9.9	6.3	16.8
	2—4	11500	13.7	6.1	18.8	6.5	25.0
	4—8	9000	10.9	4.5	27.1	1.9	33.6
				Yield—350 bu/A			
(B)							
Fert. band	2″	30600	37.1	7.6	1.5	19.6	0.6
	2—4	11450	23.6	8.8	5.7	12.0	5.5
	4—8	5650	10.2	10.6	16.7	2.3	1.8
between	2″	6650	19.0	10.8	2.7	5.8	2.7
	2—4	5000	10.0	13.1	7.0	4.4	10.7
	4—8	4800	9.6	12.5	11.6	0.3	14.7
				Yield—1300 bu/A			
(C)							
Fert. band	2″	11450	25.3	8.8	1.7	12.0	0.2
	2—4	2500	12.0	10.3	9.5	11.9	1.1
	4—8	1150	8.4	9.7	9.0	1.7	3.0
between	2″	5350	5.2	13.5	2.3	14.9	0.8
	2—4	4250	4.8	11.9	7.3	6.0	0.5
	4—8	2080	1.0	13.4	9.1	0.7	2.2
				Yield—1550 bu/A			

*A, B, C—Different locations in the same field. Fertilizer applied and samples taken as described in Table 2. N and K_2O were applied at a rate of 500 and 800 pounds per acre. Samples obtained 5/16/67.

**The NaCl tends to accumulate in the subsoil in certain locations in the field that originally were low areas and generally poorly drained.

FACTORS WE CAN CONTROL. We can put certain factors to work for the soil environment. When properly controlled, they can lead to top-profit production.

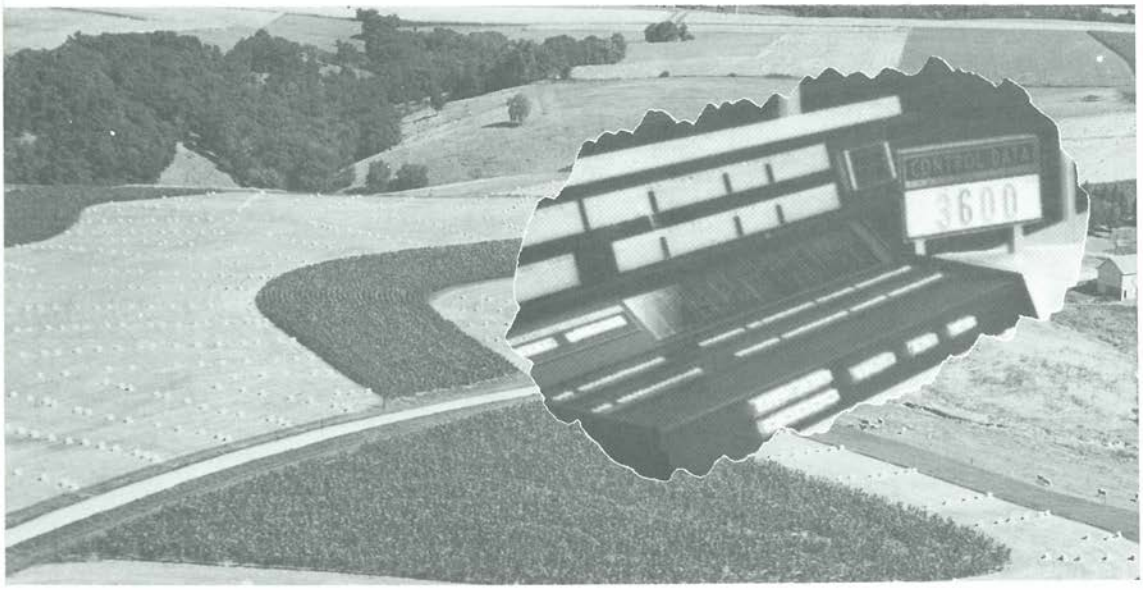
1—Larger quantities of all nutrients. Some people fear injury from excessive salt or specific ions when using more nutrients. *The key is balance.* Periods of true nutrient balance in soils are transitory at best. But one can shift soil nutrition toward the most productive intensity and balance by controlling nutrient quantities, ratios, sources, placement, and movement. Precision feeding must give the plant maximum nourishment and minimum exposure to salt accumulation.

2—Calcium from soluble sources. As more soluble nutrients are supplied, calcium uptake declines in the face of more salts and competitive cations. To lick the problem, we get calcium from sources more soluble than lime. They include gypsum and calcium nitrate and sometimes foliar calcium. We also use steps to avoid excess salts.

3—Band fertilizer with plastic mulch. For the most part, we band fertilizer on a flat-top bed so it remains in place with seep irrigation. We control the environment further by using a plastic mulch with a specific water table 15 to 18 inches below the bed surface.

In this way, one heavy fertilizer application supplies the crop, while providing almost optimum nutrient concentration in most of the soil profile. The root then develops in the top 6 to 8 inches of the bed. It spreads extensively in and around the banded nutrients, promoting a very extensive root absorption surface which speeds up production time.

THE END



Putting SYSTEM Into

J. BENTON JONES *

THE FARMER must constantly evaluate his cropping system if he is to improve his production efficiency.

And those who advise him need to know how well current crop production recommendations perform under different environmental conditions and management abilities. Most farmers lack the means of thoroughly evaluating their own operation. A systematic analysis would be invaluable to individual farmers as well as state extension and industrial agronomists who serve the farmer.

An evaluation of a functioning operation has been called "systems analysis." Such analyses have successfully evaluated industry and government businesses. Model building is the term used to describe the statistical approach.

* Formerly Professor, Ohio Agr. Res. & Deve. Center, Wooster, Ohio; now Extension Agronomist, University of Georgia, Athens, Georgia.

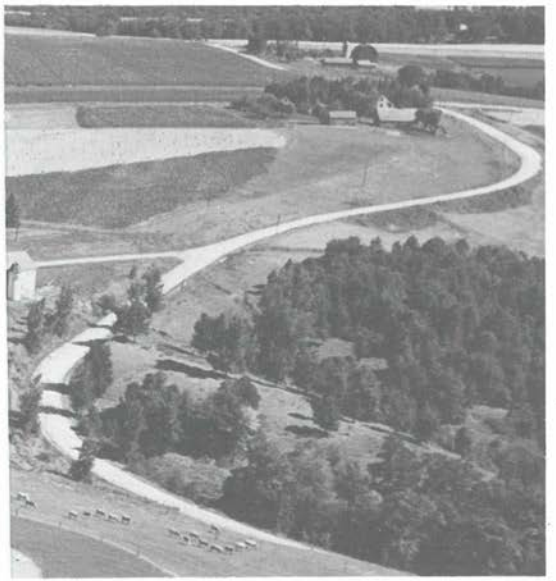
HIGH SPEED digital computers analyze the data. The end result is an evaluation of a functioning operation, pointing out relevant significant associations.

The farmer is in a model building enterprise. Beginning with a basic structure, the soil and climatic environment, he adds various inputs to the system: fertilizer, seed, herbicides, etc.

His management skill is reflected in timeliness and proper selection of inputs. His success is measured in terms of the final yield and profits. Therefore, most farming operations lend themselves to the systems analysis approach.

Several systems analysis programs have been tried during the past several years, using data gathered from Ohio farms. These programs have proved useful in evaluating production practices for several agronomic crops.

100 BUSHEL CORN CLUBS There are many 100 bushel corn clubs in Ohio. Participants are usually in one local area, with a county agent or vocational agriculture teacher serving as leader of the club. Although designed to gain some



FARMING

educational experience, most clubs produce little significant or useful data.

In 1966, corn club data from several county groups in NW Ohio were combined and analyzed statistically, assisted by the statistician at the Ohio Agricultural Research and Development Center. The most significant factors influencing yield were **planting date** and **plant population.**

A regression of yield on planting date and plant population gave some useful data one could use if considering replanting. Farmers in NW Ohio with an early poor stand are often tempted to replant. Table 1 showed them what plant population would be needed to achieve the same or higher yield if replanted.

More significant associations were found. Nitrogen rate and previous crop were significantly related to yield. The optimum nitrogen rate for continuous corn ran about 150 lb. nitrogen per acre. Corn following corn resulted in slightly lower yields than corn following some other crops.

SOYBEAN EFFICIENCY. A state-wide soybean efficiency demonstration program began in 1966. Ohio farmers interested in soybean production were encouraged to participate. An entry fee covers the cost of soil tests and plant analyses. The minimum acreage is 5 acres. Each field is well documented and carefully checked by the local county agent.

Statistical analysis of the yields with treatments and cultural practices have provided some interesting data. Table 2 shows how yield was significantly related to soil pH and available P and K. Soybean

Table 2. Association of Yield of Soybeans with Soil Test Level. Soybean Efficiency Demonstration Plots 1966 [1]

Yield Level	Soil Test		
Bu/A	pH	P, lbs/A	K, lbs/A
< 20	6.1	34	131
21-30	6.4	44	198
31-40	6.5	55	211
41-50	6.4	65	255
> 50	6.7	68	260

[1] Based on 127 observations. Correlation between yield and soil test level (pH, available P and K) were statistically significant at the 5% level.

Table 1. How Plant Population and Planting Date Affect Relative Corn Yields in NW Ohio. [1]

Plant Population	Planting Date and Relative Yield								
Plants/acre	5/1	5/5	5/10	5/15	5/20	5/25	5/30	6/5	6/10
10,000	59	57	56	54	53	51	48	46	43
15,000	75	72	70	68	66	64	62	60	58
20,000	88	86	83	80	77	74	71	68	65
25,000	100	96	93	89	85	81	78	75	73

[1] Based on 339 observations. Actual yield at 25,000 plants per acre, planted 5/1, 167 bushels per acre.

yields have always been thought to be strongly influenced by soil test level, but very little substantiating data has been available. Fertilizer treatment did not appear as a factor in determining yield.

SUGAR BEET STUDY. Results from some 200 sugar beet fields were documented for a system analysis study in 1967 by sugar company field men. Data obtained was considered highly reliable and the various statistical analyses were most revealing.

The results were enthusiastically accepted by the sugar company and a system analysis study will be repeated again. Field men were given substantive data showing the effects of soil type, cultural practices, and fertilizer treatments on sugar yield. Table 3 gives some of the more interesting and significant results.

Table 3. Factors Most Frequently Boosting Sugar Beet Yields. 1967 [1]

Previous crop: Corn
Soil Texture: Sandy
Tillage: Spring plowing
No. of cultivations: 3 to 5 times
Seed Depth: < 1.0 inch
Herbicide Applied: Yes
Side dressed with N: No
Planting Date: Before May 1
Weed control obtained: Good

[1] Soil test levels were high in most fields and not factors in determining yield. Date planted was the most significant factor influencing yield. Based on 193 observations.

DISCUSSION In these three examples, systems analysis provided interesting and valuable data for advising farmers on the effects of various treatments and factors on yield. For the corn farmer, the influence of planting date and plant population was dramatically illustrated by a statistical analysis of data from over 300 corn fields in NW Ohio.

The results from this as well as other analyses carried much weight among those farmers. The input data came from their fields and the results reflected their conditions.

Frequently farmers are reluctant to accept results obtained on small experimental plots on research farms and experiment station sites.

A successful systems analysis requires well documented data taken by reliable observers. It requires a computer and statistical assistance in describing the model and statistical approach.

Proper evaluation of the statistical results requires careful sorting of irrelevant but significant associations which lack biological reasonableness. Frequently confounded associations can cloud an explanation of significant yet unexpected correlation. The statistician and agronomist must have much skill to evaluate results from a systems analysis. The only limitation would be the limits to the imagination of the analyst.

IN SUMMARY Systems analysis can be used to evaluate a farmer's crop production enterprise. Every farm becomes an experimental plot. If each farmer operation is properly documented, a systems analysis can be invaluable to each individual farmer and the agronomist advising him.

The significant effect of each input can be properly evaluated. A systems analysis will either support current recommendations or point out new areas for additional research. Unexpected asso[illegible]tions may occur which require caref[illegible] evaluation.

But the end result can be [illegible] tions and practices that will boost the farmer's profits and production efficiency.

THE END

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See Page 20

SAVED Money Is MADE Money

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POTASSIUM BUILDS ALFALFA QUALITY, D-1-68	_____	_____
POTASSIUM BUILDS GRAPE QUALITY, E-1-68	_____	_____
POTASSIUM BUILDS COTTON QUALITY, F-1-68	_____	_____
POTASSIUM BUILDS RICE QUALITY, H-1-68	_____	_____
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Leaf Analysis

Leads To NEW Profits In PRUNES

- **They picked five mid-terminal leaves about shoulder high from each "check" tree.**
- **When fertilized trees started doubling their yields, limb breakage had to be watched.**
- **One grower was so pleased that he fertilized his whole orchard—then jokingly threatened to send the specialist a bill for the fruit he did not produce on the unfertilized ("check") trees.**

ROBERT L. STEBBINS
OREGON STATE UNIVERSITY

WHEN A new fertilizer program gets 10 to 15% more yield out of each acre these days, it's big news. It gets wide coverage. But we don't hear much anymore about fertilizer alone boosting average yield 50 or 100%.

That's what makes recent fertilizer demonstrations on Oregon prunes big news. Fertilizer boosted yields OVER 100%. Why? Because teams of county agents, fertilizer dealers, and college specialists found widespread nitrogen, boron, and potassium hunger in the Italian prune orchards of Western Oregon.

We conducted a leaf analysis survey of 177 orchards. The Soil Improvement Committee of the Northwest Plant Food Association co-sponsored and financed the program.

We selected and tagged 10 trees of average size and vigor in each orchard—nearly 1,800 trees. We picked five mid-terminal leaves from each tree about shoulder high. We then wrapped each sample of 50 leaves in a moist paper towel and placed it in an ice chest. The leaf analysis laboratory of Oregon State University's Department of Horticulture prepared the samples for analysis.

The tests, based on leaf nutrient levels established by Dr. O. C. Compton's fertilizer trials on Western Oregon prune orchards, showed widespread nutrient hunger. **Table 1 shows how widespread.** We sent each grower the bad news along with a fertilizer recommendation. We also set up 22 demonstrations in growers' orchards.

DYNAMITE DOSES OF NITROGEN. In the first year, we realized ¾ lb. nitrogen per tree was not nearly enough to correct hunger. So we applied up to 6 lb. actual nitrogen per tree the second year, depending on leaf nitrogen level, of course. **By August, 1966, nitrogen levels had improved greatly, as Table 2 shows.**

Although nitrogen was applied in February, leaf nitrogen seemed to increase the most 18 months after application in

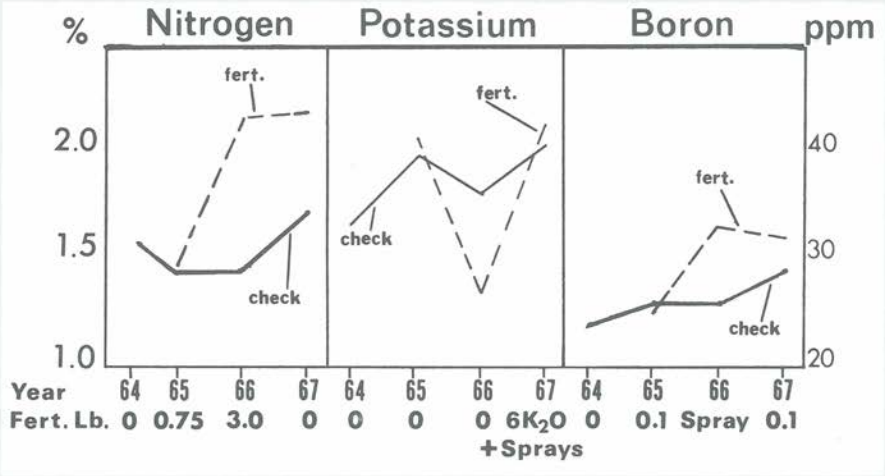

FIGURE 1—N, B, K LEVELS, WEPSTER ORCHARD

Heavy N Fertilization Pulls Down K Level Until K Fertilizer is Applied to Soil and Foliage to Bring K Level Back Up

these non-irrigated orchards. We learned a big lesson. If you want to correct severe nitrogen hunger quickly, apply a "dynamite" dose. Even the heaviest rates did not affect the trees adversely.

FOLIAR BORON FASTER. Soil applied boron (0.1 lb./tree) increased boron levels very little the first year. A year later, some orchards still suffered boron hunger.

To increase B levels more rapidly, we sprayed sodium pentaborate at 2 lbs./100 on all fertilized plots. Some orchards with 30 ppm boron in August showed boron hunger at blossom time. So, we decided to raise leaf boron standard to 35 ppm or above. We applied boron to the soil again in 1967, but leaf B levels did not rise above 35 ppm in most cases.

POTASSIUM UPTAKE SLOW. In potash-hungry orchards, we applied 10 lbs. muriate of potash per tree in a band about a foot wide under the drip line of the

Table 1. Italian Prune Leaves in August

	Nitrogen	Potassium	Boron
Optimum level	1.8—2.0%	above 1.5%	30 ppm
% Orchards Deficient	77	15	64

Table 2. Leaf Nitrogen and Application Rates

Orchard		1964	1965	1966	1967
#2	leaf N	1.64	1.69	2.00	2.10
	lbs. N applied	none	0.75	3.0	0.75
#3	leaf N	1.68	1.66	1.88	2.12
	lbs. N applied	none	0.75	1.5	0.75
#17	leaf N	1.54	1.84	2.34	1.84
	lbs. N applied	none	3.25	0.75	none
#12	leaf N	1.52	1.36	2.48	2.28
	lbs. N applied	none	0.75	6.0	none

branches. Leaf K and foliage appearance improved some the first year and some more after a second application of the same amount. But in some plots, even these heavy, concentrated applications did not raise K levels above 1.5 percent.

Summer sprays of KNO_3 improved foliage appearance and seemed to increase leaf K more rapidly than soil application alone.

Increasing N level usually reduces K. So, increasing both N and K at once is very difficult. **In Figure 1, heavy N fertilization pulls down K level until K fertilizer is applied to soil and foliage to bring K level back up.**

When fertilized trees started doubling their yields, limb breakage became a problem. **Table 3 shows the great surge in fruit tons.**

Table 3. Yields In Wepster Orchard

	No Fertilizer	Fertilizer
tons	4.5	10.8

YOUNGER ORCHARDS TAKE OFF. When we started the project, we thought that young relatively vigorous orchards might show some response but old "starved" ones would improve most dramatically. The opposite happened.

A young orchard only moderately deficient in nitrogen and boron increased its yield first. **Table 4 shows this response.** Mr. Parrish was so pleased with the results that he fertilized his whole orchard —and jokingly threatened to send us a bill for the fruit he did NOT produce on the ten UNfertilized "check" trees.

Table 4. Yields In Parrish Orchard

No Fertilizer	Fertilizer
Tons/A 1965 1.76	2.54
Tons/A 1966 6.00	9.00

FRUIT QUALITY IMPROVES. Growers feared fertilizer, especially nitrogen, would ruin fruit quality. So, we brought hundreds of fruit samples to the OSU lab to check out for size, firmness, sugar content, and internal color. The Food Technology Department's Flavorium tested canned samples.

Aside from delayed maturity, quality was as good or better than fruit from nonfertilized checks. Mr. Parrish reported his dry-away ratio (a reflection of fruit size and maturity mainly) was higher. And, he further explained, "It is evident the program has not only benefited me with increased yield, but has strengthened the trees, giving me a far healthier orchard." **Table 5 cites three orchards where fertilization increased sugar content of fruit.**

Table 5. Soluble Solids (Mostly Sugars) of Prunes

Orchard	Year	No Fertilizer	Fertilizer
Keightly	1965	20.7	21.7
Allison	1965	14.9	17.0
Hunsaker	1966	21.5	23.2

Potassium boosted fruit size greatly in Dr. Compton's experiment in 1967. **Table 6 shows this influence.**

Table 6. Potassium Influence on Fruit Size

	N & Boron	N, Boron, & K
Weight, 20 fruits, Grams	177	316

SOME ORCHARDS STUBBORN. Some orchards failed to respond. Why? Excessively deep cultivation was the most frequent reason. Fertilizer could do little for old trees weakened by root rots and general neglect. Fertilizer is no substitute for good orchard management. The age of trees was not nearly as important as the care they had received.

GROWERS NOT STUBBORN. This program has sold most serious commercial prune growers of Oregon on using leaf analysis as a farming tool and fertilizing according to the needs it turns up.

The Oregon State University Diagnostic Service received only 250 leaf samples in 1963, but more than 1,300 samples last year. Growers are shifting from small amounts of various mixes or no fertilizer at all to substantial applications of nitrogen, boron, and potassium. And their orchards are agreeing with them—100% sometimes.

THE END

ALFALFA Can Be Grown

C. J. OVERDAHL
UNIVERSITY OF MINNESOTA

ALFALFA CAN BE grown successfully and profitably on most sandy soils in Minnesota. But to do it, lime and fertilizer treatments must be much higher than most people, even professional workers, ever imagined.

Since experimental work began in the northeastern third of the state, potash recommendations for low-testing soils have climbed from 90 lb. per acre to 360 lb. of K_2O at seeding time plus 180 pounds annually for maintenance. We urge it for most efficient production.

TABLE 1. Alfalfa yields in tons per acre and related costs and profits according to varying 1963 treatments with no further potash top-dressing and the 1964, 1965, and 1967 yields.

		1963 Seeding time rates of K_2O, pounds per acre				
Year	Cuttings	0	60	120	180	240
1964—tons/A	2	2.31	2.40	2.60	2.70	3.00
1965—tons/A	3	4.02	4.16	4.50	5.08	5.36
1967—tons/A	3	1.32	1.23	1.32	1.70	1.71
3-year yield total—tons/A		7.65	7.79	8.42	9.48	10.07
Potash—cost/A		0	$2.40	$ 4.80	$ 7.20	$ 9.60
3-year increase—tons/A		0	.14	.77	1.83	2.42
Value of increase at $18/ton		0	$2.52	$13.86	$32.94	$43.56
Hay value increase less potash cost (3-year total)—$/A		0	$ .12	$ 9.06	$25.74	$33.96

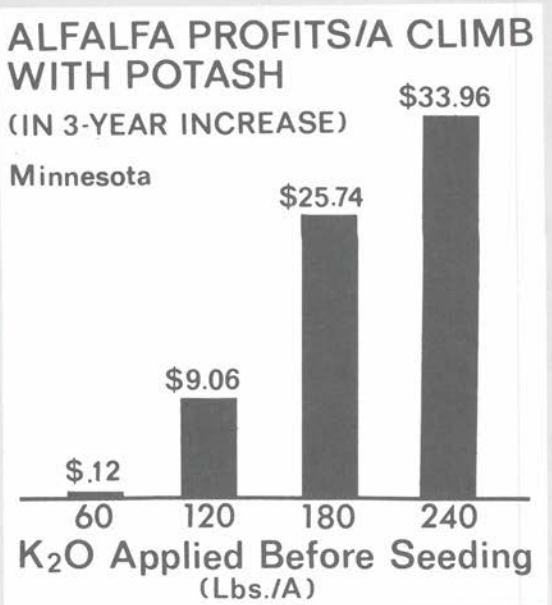

TABLE 2. The effect on yield of alfalfa from annually topdressed treatments of potassium (20 observations for each treatment).

Year	No. of Cuts	Rates of K_2O topdressed annually—lb/A: 0	120 Tons/A	240
1965	3	4.81*	5.65	6.05
1967	3	1.74*	4.08	4.53
1968	3	1.41	4.88	5.46

*Average yield of all plots that received the initial potash treatments in 1963.

FIGURE 1

PROFITABLY On Coarse Soils

Lime recommendations have about doubled in 10 years. At one plot site testing pH 6.3, profitable responses came from 2½ tons of lime per acre. This brought the pH average to 6.7. When a 5-ton lime treatment raised the pH to 7.0, alfalfa gave profitable yields beyond the 6.7 pH level.

Experimental plots on non-irrigated sandy loams in north central Minnesota show what can be done.

SEEDING TIME K TREATMENTS. Table 1 shows profits from various potash treatments made at seeding time in 1963. Benefits were gone after three crop years. Even 240 lb. K_2O gave small yield differences in 1967. Soil tests, tissue tests, and yields in 1967 showed no major differences from check plots.

POTASSIUM TOPDRESSING. The plots at Pierz were designed to be split three ways and after 1964 were topdressed annually at 0, 120, and 240 lb. of K_2O. Each year all plots in the potassium experiment received 60 lb. of P_2O_5 per acre, except in 1967 the treatment was increased to 120 lb. In 1963 and 1967, all plots received 300 lb. borated gypsum, supplying 50 lb. of sulfur and 4½ lb. of boron per acre. Plots receiving the five initial potash rates were not topdressed, and they show little yield differences. So, we increased observations for each topdressing treatment from 4 to 20. **Table 2 shows the large yield differences in 1967, converted to profits in Figure 1.**

Table 2 averages yields for each annual topdressing treatment across all 1963 potash treatments. The 1963 potash rates were still getting good response in 1965. This accounts for the very high check plot yields that year. Effects of the initial treatments were not apparent after the third year.

As K content in the tissue declined from no topdressing in fall, 1967, it became statistically important at the 5%

.e last of four annual potassium topdressings affected alfalfa yield
ıe alfalfa tissue the following year.

	Annual rates of K_2O—lb./A				
	0	120		240	
1968 alfalfa yield—tons/A	1.41	4.88	3.98*	5.46	5.09*
K in tissue—%	.93	1.96	1.48*	3.12	2.21*

*Topdressing omitted only in the fall of 1967.

level, shown in Table 3. Potassium soil tests (as exchangeable K) in 1967 were as follows: no K = 30 lb./A, 120 lb. of K_2O = 173 lb./A, 240 lb. K_2O = 325 lb./A.

PHOSPHORUS RESULTS. There were 24 observations for each phosphate treatment in the lime and phosphorus experiment. These were reduced to 12 in 1968 when treatments of 45 and 120 lb. P_2O_5)68, there was no significant increase from 120 lb. P_2O_5 over 60 pounds. **Table 4 shows the influence of phosphorus.**

LIME RESULTS. Table 5 shows that lime was profitable on 6.3 pH soils. And by raising pH above 6.7, even greater profits can be obtained. Benefits should continue many years without further lime.

NUMBER OF CUTTINGS PER YEAR. In northern Minnesota, farmers have found it difficult to take three cuttings

ɔsphorus affects average alfalfa yield in 1964, 65, 67, 68, as well as soil
.est. Adequate lime, K, S, and B added,

	Annual treatment P_2O_5—lb/A		
	0	30	60
Average yield annual increase—tons/A	....	.91	1.27
P tissue—%	.19	.23	.28
P soil test*—lb/A	16	18	27

*Bray P test.

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yield increases in tons/acre from 1962 lime treatments. Adequate .dded.

	Limestone	
	2.5 Tons/A	5 Tons/A
Total yield increase, 11 cuts—tons/A	1.96	2.73
pH (no lime=6.3)	6.7	7.0
Increased value of hay at $18/ton	35.28	49.14
Lime cost at $5/ton*	12.50	25.00
Increased profit—$/A	22.78	24.14

safely. In our first crop year in 1964 at Morrison county, drouth prevented a third cutting. Yields exceeded 6 tons per acre in 1965. That year we took 3 cuttings and lost the 1966 crop to winterkill from a February ice storm and heaving. We re-established the stand and in the third cutting of 1967 took only a sample from half of each plot and left the remainder uncut.

did not have winterkill but measured a serious set-back on the lower potash topdressing where the third cutting was taken. **There was less reduction with the higher K_2O rate, shown in Table 6.**

ACKNOWLEDGEMENT is due to Gyles Randall, who assisted in plot work and made statistical analysis; to L. D. Hanson in assisting the establishing of the project; and to Roderick Boser, the farm cooperator for excellent cooperation with field work and use of his land.

THE END

cuttings affected the following year's alfalfa yield and relationship to ressing levels. (1st cutting only).

Cuttings Preceding Year	K_2O Topdressing—lb./A 120	240
	tons/A	
2	1.92	2.15
3	1.44	1.86
1st cutting yield loss	.48*	.29*

*Yield loss was highly significant.

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Mineral Deficiencies CHANGE Organic Acids

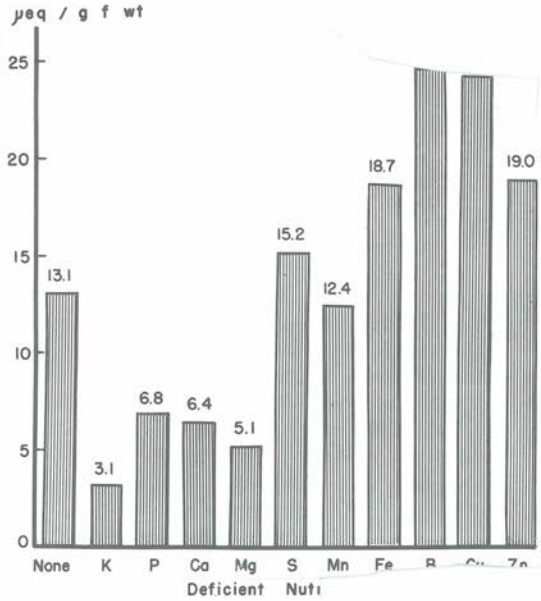

FIGURE 1. Trans-acon of mineral deficient

RALPH B. CLARK
WOOSTER, OHIO

THE BASIC METABOLISM of plants changes whenever they suffer mineral deficiencies.

Organic acids are affected by deficiencies. Changes in organic acids due to deficiencies have not been studied nearly as much as changes in amino acids or sugars.

Common organic acids of plants are those found in the Krebs or tricarboxylic acid cycle: malic, citric, isocitric, succinic, fumaric, cisaconitic, alpha-ketoglutaric, and oxaloacetic acids. Certain other acids (not directly associated with the Krebs cycle) prevail in some plant species.

THE IMPORTANCE of organic acids in plant metabolism can be noted when one considers that after carbon dioxide assimilation, the starting compounds for synthesis of nearly all plant components are organic acids. Proteins, carb
acids, and other complex molecules originate from organic acids.

With the exception of acetate, organic acid molecules themselves are not built one upon another into long chain polymers like the amino acids and sugars, but are used directly to form the amino acids and sugars that can combine one to another to form complex molecules.

The importance of organic acids is also revealed by these facts:

1. That nearly three-fourths of all carbon metabolized by an organism passes through a two-carbon intermediate (acetyl CoA) which feeds into the Krebs cycle.

2. That nearly 90% of all nitrogen fixed by a plant combines with alpha-ketoglutaric acid to form glutamic acid (an amino acid).

3. That nearly all cyclic compounds originate from Krebs cycle acids.

4. That respiration, the process that produces most of the energy for plant metabolism, uses Krebs cycle acids directly.

Recent evidence indicates carbon assimilated in photosynthesis by tropical plants (corn and sorghum included) forms

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Dr. Ralph B. Clark, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, and Department of Agronomy, Ohio Agricultural Research and Development Center, Wooster, Ohio 44691, Journal article No. 69-68. A more detailed presentation of this material may be found in Crop Sci. 8:165-167 (1968).

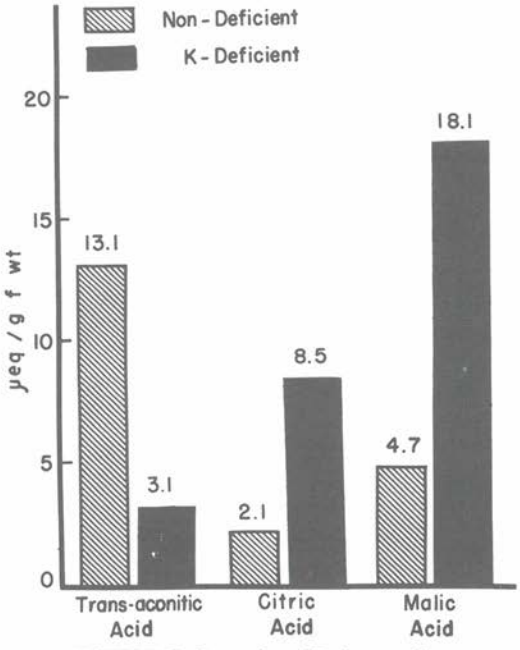

FIGURE 2. Organic acid changes between non-deficient and K-deficient corn leaves.

malic acid before being synthesized to sugars.

IN THIS STUDY young corn plants were grown in nutrient solutions under various mineral deficient conditions for 10 days. Leaves were harvested and organic acid analyses made. The major portion of the organic acid fraction consisted of trans-aconitic, malic, and citric (isocitric included in citric) acids; transaconitic acid being the predominant acid.

Trans-aconitic acid contents changed considerably with the mineral deficiencies and the results are shown in Figure 1. Changes in malic and citric acid contents due to the deficiencies, except for potassium, were not as great. **Acid changes due to potassium-deficiency are given in FIGURE 2.**

ONE OF THE SIGNIFICANT findings of this study was the decreased trans-aconitic acid content in the leaves when the plants were deficient in macro-nutrients, especially potassium.

Under potassium-deficient conditions, trans-aconitic acid decreased four-fold while simultaneous four-fold increases in malic and citric acids were noted. Trans-aconitic acid also decreased in phosphorus-, calcium-, and magnesium-deficient leaves—but malic and citric acids did not increase as much as trans-aconitate decreased. Increased trans-aconitic acid contents were also noted for the micronutrient deficiencies.

MANY POSSIBLE REASONS could be suggested to explain the observed effects of the mineral deficiencies noted. One reason lower trans-aconitic acid contents were found in mineral deficient plants could be because the carbon units entering the Krebs cycle were not being converted to trans-aconitic acid or the synthesized trans-aconitic acid was being metabolized to other products.

Decreased trans-aconitic acid contents might be expected if the amount of acetyl CoA entering the Krebs cycle was reduced or if the amount of carbon entering the cycle was used by the regular Krebs cycle enzymes rather than in synthesizing trans-aconitic acid.

Low amounts of acetyl CoA might be expected in potassium-deficient plants since it is synthesized by an enzyme (pyruvic kinase) which requires potassium for maximum activity. If trans-aconitic acid synthesis is an enzymatic process, the enzyme might also require potassium for maximum activity.

Higher organic acid contents in mineral-deficient corn leaves, especially in potassium-deficient leaves, could also be explained on the basis of reduced protein synthesis which could lead to a build-up of free amino acids. Since amino acids are synthesized from organic acids, the organic acids could build up as well.

ONE REASON FOR lack of information about trans-aconitic acid in plant metabolism is that this acid has been noted in plants in just recent years. Methods of detection and analysis have also been limited.

Trans-aconitic acid is not a normal product or intermediate of most commonly recognized metabolic pathways.

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What Is

R. J. HILDRETH
FARM FOUNDATION

HAVE AMERICAN FARMERS exhausted ways to boost profits from fertilizer use? Or do they have new ways to make fertilizer use even more profitable?

When deciding how much fertilizer to apply, the farmer usually estimates three things:

1—The crop response expected from various rates and combinations of fertilizer applications.

2—The cost of fertilizer, along with application.

3—The expected price of the crop.

With these estimates under his hat, he applies the added cost-added return rule to decide how much plant food to use. This rule says to add plant food units as long as added returns from the added units exceed the added costs—that is, as long as added income exceeds added cost, profit increases.

Figure 1 shows a family of response curves for various nutrients and combinations of nutrients included in fertilizer. These will vary with the crop and other practices. Nutrients also interact with other management practices to produce responses and change the shape of the curves, which completely change our thinking on profitable fertilizer rates. With yield curve A_1, fertilizer rate A was adequate to give Y_1—but with yield curve C_1 a much higher fertilizer rate (C) gave Y_3 and was most profitable.

However, the basic decision rule of added returns-added cost still applies. **Figure 2 gives a visual example.**

In Figure 2, applying nutrient A alone produced no response. Adding nutrient B alone increased yield, but also enabled the farmer to make profitable use of moderate rates of A. Adding nutrient-practice C with the given B level made use of the highest A level profitable.

Concrete examples of these types of interactions are available. **Figure 3 shows the interaction of N and K on a low-K soil.**

Many factors affect the ability of a crop to respond to a nutrient or nutrients in fertilizer. They affect tillage practices, drainage, weed control, insect control, crop variety, climate, irrigation, soil pH, plant stand, planting date, lodging, time and method of application, as well as level of nutrients in the soil before fertilizer is applied.

Many of these factors can be controlled by the farmer. Others, such as weather, have to be accepted as part of the uncertainty associated with farming.

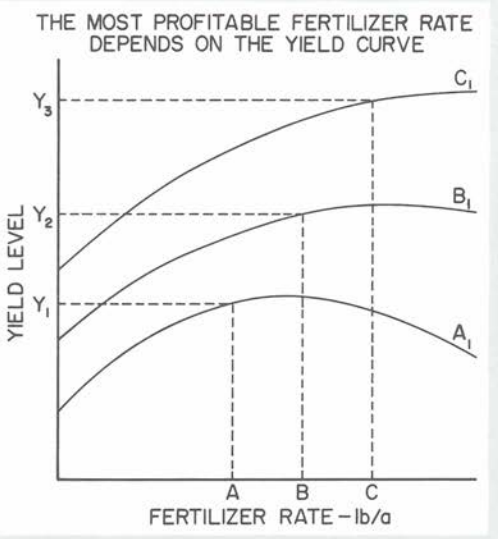

FIGURE 1. As management practices are changed to increase yield level, fertilizer requirements increase.

COST OF WRONG DECISIONS. In deciding how much fertilizer to apply, the cost of the fertilizer and its application can be estimated fairly accurately. But neither response nor price one will receive for the product can be estimated very accurately.

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