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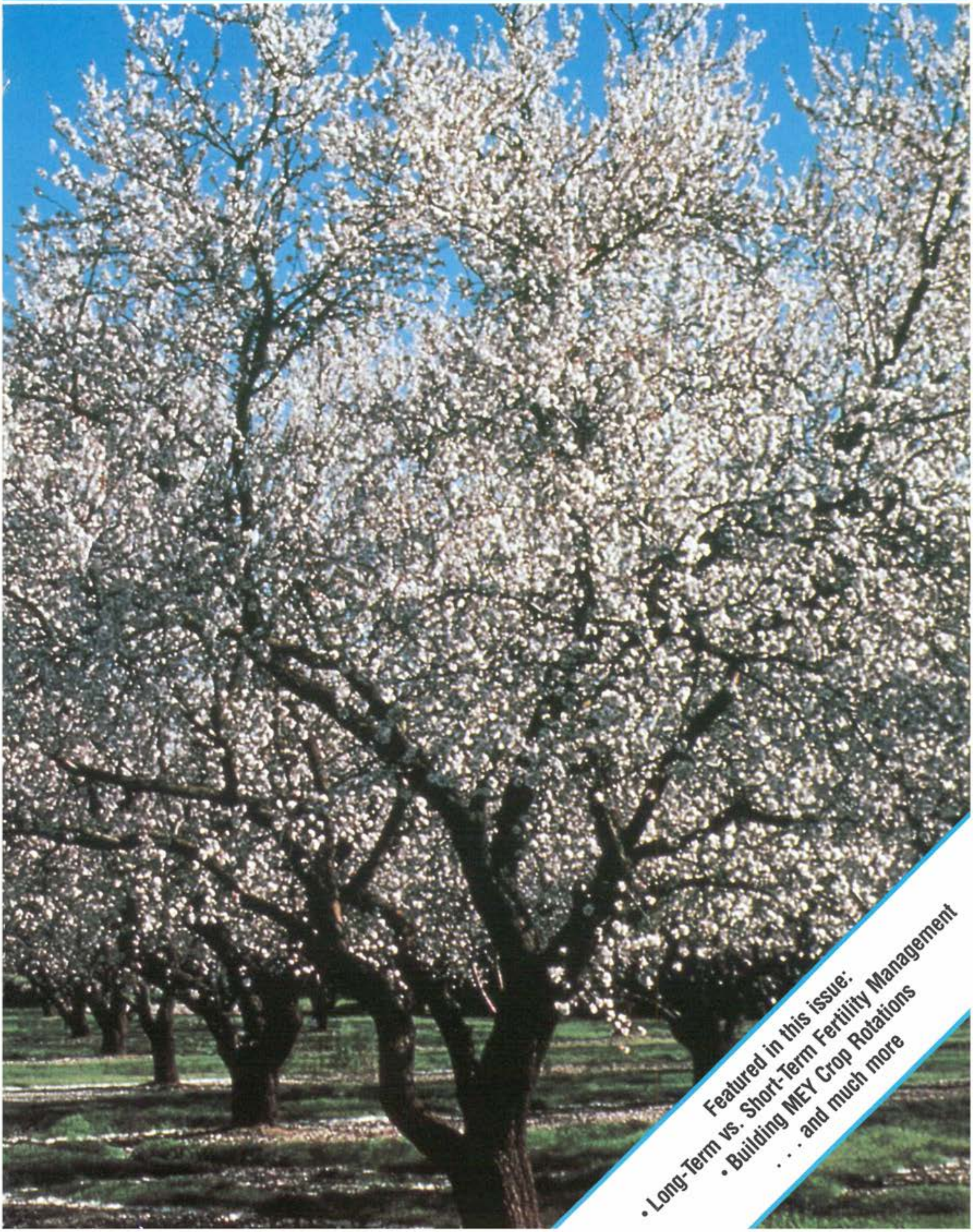
BETTER CROPS

WITH PLANT FOOD

Spring 1992



Featured in this issue:
• Long-Term vs. Short-Term Fertility Management
• Building MEY Crop Rotations
. . . and much more

BETTER CROPS With Plant Food

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Contents

Our Cover: Almond trees display their blossoms in a California orchard near Merced in the San Joaquin Valley. See article on page 3 for some comments on almond fertilization from a top grower. Photo by Dr. A.E. Ludwick.

Almond Grower Says Soil Fertility Is Key to Higher Yield

ALMONDS are Ron Piazza's only business. He grows almonds on his own land, leases almond orchards, manages almond orchards, manages orchards for other property owners and runs a commercial hulling plant. In all, he farms about 450 acres of almonds around Denair, CA, in the San Joaquin Valley.

His wide experience in almond production has provided some insight as to the various levels of success of growers. The differences in some cases are extreme, with a yield variable of 1,000 lb/A or more.

"When you do this type of analysis, you have to look at all the crucial factors: almond varieties grown and planting patterns, soil type, irrigation practices, and so forth. Then you have to go back and compensate for the variables and identify tree blocks which should have roughly equal production potential," Mr. Piazza says.

The more informal research he did, the more interesting it became, and the more growers he talked to. The net result of his observations led Mr. Piazza to conclude that an almond grower's fertility program is the single biggest factor accounting for varying yields "when all other factors are reasonably equal."

ALMOND GROWER Ron Piazza at his hulling plant.

He says growers seem to fall into three basic categories when it comes to fertilization practices:

A. Growers with low-producing orchards who use minimal amounts of straight nitrogen (N) with little or no potash (K).

B. Growers in middle production group – by far the largest – who make ample use of N and supplement periodically with K and occasionally with phosphorus (P).

C. Growers in this relatively small group have the highest yields and use a full fertilizer with N, P, and K. "These growers religiously use a complete fertilizer with a guaranteed analyses of those three nutrients every time they fertilize – whether two or three time a year."

The increased yields enjoyed by the "C" group far outweigh the extra cost for fertilizer, Mr. Piazza believes. The "C" group probably spends $250 per acre per year vs. $125 per acre for the middle group. The "A" group growers usually spend less than $100 per acre each year, he estimates.

While the low-fertilizer growers never harvest more than 1,500 to 2,000 lb/A, the high-fertilizer orchards have produced "on specific varieties in specific years, over 4,000 lb/A. Yet they have the same age and variety trees, the same soil profile and the same amount of water as the others." ■

Adapted and reprinted with permission from *Almond Facts*, January/February 1992 edition, published by Blue Diamond Growers Association, Sacramento, CA.

A Systems Approach to Building MEY Crop Rotations

By F. Ronald Mulford and William J. Kenworthy

Research is proving that each crop in a "3-crop/2-year" rotation can show significant yield increases with enhanced fertility, supplemental water, and appropriate variety selection.

A POPULAR ROTATION in the mid-Atlantic states includes corn, wheat and doublecropped soybeans. The "3-crop/2-year" system is ideally suited to the soils and climate of the area. All three crops are utilized by the large livestock and poultry industries located in the region. Increased production of these crops is a desirable goal because all three must be imported into the grain-deficit region to meet feed needs.

Yields of 110 bu/A corn, 50 bu/A wheat and 30 bu/A doublecropped soybeans are the average on the Delmarva Peninsula. Farmers with irrigation equipment for corn, and those that have adopted some of the intensive wheat management practices, consider 175 bu/A corn, 75 bu/A wheat, and 45 bu/A doublecropped soybeans as above average yields.

Higher yields can be profitably produced in the region in cropping systems that will protect the environment. We began studying ways to improve wheat production in 1980 and have been able to produce yields over 100 bu/A each year, regardless of weather patterns. Similar studies in Virginia and North Carolina have also shown that wheat yields can be profitably increased. Other maximum economic yield (MEY) studies on corn and soybeans in Maryland, New Jersey, North Carolina and Virginia have also proven successful. **The important next step is putting these MEY production packages together**, just as the farmer has to do. A systems approach to building a productive and environmentally safe "3-crop/2 year" rotation has been the objective of our 3-year study.

Systems Research Results

The study is located on a Matapeake silt loam soil on the Poplar Hill Research and Education Facility. Each year, half the experimental site is used for corn and half for wheat followed by doublecropped soybeans. We are looking at several variables on each crop and trying to incorporate those practices which prove best for the crop and the cropping system.

Corn Production Practices

Our MEY Yield Goal:	250 bu/A
Top Systems Research Yield:	222 bu/A
Three-year Avg. Systems Yield:	207 bu/A
Today's Good Farmer Yield:	175 bu/A

Hybrids and Row Spacing. Ten corn hybrids (five mid-season and five full season) were planted on May 14 in 15- and 30-inch rows with a final population of 31,000 plants per acre. With more intensive management, narrow rows have produced significantly higher yields. Also, hybrid variability to row spacing has been substantial (**Table 1**). Eight of the 10 hybrids averaged over 10 bu/A more when planted in 15-inch rows.

Fertilization. The objective is to eventually achieve 250 bu/A irrigated corn in

Mr. Mulford is Manager of the Poplar Hill Facility of the Lower Eastern Shore Research and Education Center, Quantico, MD. Dr. Kenworthy is Professor of Agronomy, Department of Agronomy, University of Maryland, College Park, MD.

Table 1. Yield response of corn hybrids to row spacing.

	Yield, bu/A		
	15-inch rows	30-inch rows	Mean
Top hybrid	221.8	210.8	216.3
Top 4 hybrids	210.4	200.7	205.6
Eight hybrids	193.4	182.8	188.1
Two hybrids	190.7	193.4	192.1
Bottom hybrid	166.9	147.4	157.2
Test Average	192.9	184.9	188.9

the production system. We want to achieve our yield goal with the highest possible level of input efficiency. That means that the high rates of fertilizer (**Table 2**) must provide nutrient balance and be applied at the optimum time for efficient utilization. Soil test levels for phosphorus (P) and potassium (K) are high in the plot area. Sidedress applications were made by injecting a custom blended fertilizer solution with Yetter coulters mounted on a 3-point hitch toolbar. For the 30-inch row spacing, a coulter was used between each row. For the 15-inch row spacing, a coulter was run between every other row.

Table 2. Corn fertilization program in a "3-crop/2-year" rotation system.

Application time and method	N	P_2O_5	K_2O	S	B	Mn	Zn	Cu
	-------------			lb/A				------------
Preplant broadcast	60	40	40	20	-	6	2	2
With herbicide (preemergence)	-	-	-	-	1	-	-	-
Sidedress 5-leaf	110	20	60	10	-	-	-	-
Sidedress (row closer)	70	20	60	10	-	-	-	-

To achieve the 250 bu/A goal, higher rates of nitrogen (N) may be required, and will be introduced in 1992. Also, N source will be modified in 1992 to provide a higher ratio of ammonium-N to nitrate-N, particularly in the pre-tassel growth period. We believe 250 bu/A is a realistic goal . . . utilizing narrow row spacing, high plant populations, high soil test P and K, split applications of N, P, K and S, irrigation scheduling, and our IPM program for weeds, insects and diseases. However, as N rates are increased there is a legitimate concern over the potential impact on nitrate leaching.

Residual nitrate studies are planned, comparing a conventional corn production system with the MEY cropping system. Soil samples were taken in 1991 to a depth of 36-inches in 12-inch increments to measure residual soil nitrate-N at the test site. For comparison, measurements were taken from an adjacent field where the same hybrid was planted no-till on the same soil type with a currently recommended fertilizer program, including 120 lb/A N. Residual soil nitrate levels were relatively low under both the conventional and the MEY system (**Table 3**).

Table 3. Residual soil nitrate-N samples following corn harvest in 1991.

	Nitrate-N, lb/A	
Sampling depth, inches	Irrigated MEY system	Dryland conventional system
0-12	31.9	29.1
12-14	22.2	18.5
24-36	14.8	9.5
Hybrid—Pioneer 3241 in 30-inch rows	211 bu/A	134 bu/A

Rotations. Rotation studies conducted at Poplar Hill since 1981 to evaluate several cropping systems have shown that no-till corn planted into a wheat and doublecropped soybean stubble continuously produces the best yields. This includes yields of corn planted into a winter cover crop of hairy vetch. This is significant when one considers there is no expense involved for the wheat/soybeans stubble which provides a natural mulch following harvest of the two crops, as compared to the cost for establishing a legume winter cover crop. This rotation also provides a wheat crop following corn that will take up around 30 to 35 lb of residual N not utilized by the corn.

Wheat Production Practices

Our MEY Yield Goal:	125 bu/A
Top Systems Research Yield:	127 bu/A
1991 Yield from Field-size Systems Study:	96 bu/A
Today's Good Farmer Yield:	75 bu/A

The MEY wheat production package

has been well documented and will not be repeated in detail. Many farmers are adopting the intensive wheat management system, and record state average yields the past two years (51 and 53 bu/A) reflect this change. Several key factors are important to the consistently high yields being achieved in the mid-Atlantic region. These are (1) the selection of a high yielding, disease resistant variety from statewide variety trials; (2) following planting recommendations to achieve a uniform and vigorous stand; (3) soil testing and bringing soil nutrient levels into the high range; (4) using a scouting program to control weeds, insects and diseases when thresholds are reached; (5) using a growth regulator in combination with split applications of N when needed; and (6) paying strict attention to N management, including rate, source and timing.

It is essential to include the amount of residual soil N in the total N recommendation to help assure the most efficient N utilization. Soil N levels vary a great deal from one soil type to another in the region. Nitrogen applications should be adjusted to account for residual N levels, and split N applications in the spring must be timed to correspond to growth demands.

Doublecropped Soybean Production Practices

Our MEY Yield Goal:	65 bu/A
Top Systems Research Yield:	61 bu/A
1991 Yield from Field-size Systems Study:	50 bu/A
Today's Good Farmer Yield:	45 bu/A

Doublecropped soybean yields are the key to the success of the "3-crop/2-year" rotation. Farmer yields with doublecropped soybeans have historically been low because of the relatively short growing season, low moisture supplies and low fertility. Soybean yields can be increased by careful consideration of all cultural practices, including variety selection, irrigation and balanced fertility.

To maximize yields, soybeans must be planted as soon as the wheat is harvested. Each day's delay in planting can reduce yields. In Maryland, doublecropped soybean planting following wheat usually occurs during the first week in July. An unusually warm spring in 1991 hastened wheat maturity and permitted planting on June 21. The resulting doublecropped soybean yields were close to 60 bu/A in our best plots.

No-till planting helps reduce the time between wheat harvest and soybean seedling emergence. Soil moisture is preserved by no-till planting which facilitates quick germination and seedling emergence.

Row spacing is another important cultural practice which has a large effect on doublecropped soybean yields. Row spacing must be less than 20 inches to permit quick canopy closure, moisture conservation and maximum yields. Solid seedings (7-inch rows) are probably the ultimate goal, but reliable no-till drills are just now becoming available. We have been using a row spacing of 15 inches in our studies, with a seeding rate of 6 seeds/foot or about 209,000 seeds/A.

Irrigation. Farmers who could benefit from buying irrigation equipment for both soybeans and corn would be much more likely to purchase the equipment. Our irrigation treatments began at flowering to try to limit undesirable increases in vegetative growth. In 1991, five varieties averaged 56 bu/A with irrigation and 46 bu/A without. Irrigation did not increase plant height or lodging. Since length of growing season is a limiting factor, irrigation may play a role in helping to lengthen the time to maturity. Our results showed that maturity was delayed about 4 days by irrigation, with a beneficial lengthening of the seed filling period. These varieties responded to the irrigation treatments by producing more seeds per plant and larger seeds.

Varieties. The five varieties tested in the system were selected for their excellent yielding ability, but significant yield differences and responses to treatments occurred (**Table 4**).

Fertilization. Many farmers supply the nutrient requirements for the double-

A NATURAL MULCH of plant residue remains on this plot from harvesting wheat and no-till doublecropped soybeans. The mulch gives excellent protection against soil and water erosion during winter. Over a period of years, corn planted no-till into the mulch has yielded 15 to 20 bu/A more than corn planted after plowing the mulch under.

Table 4. Yields of five soybean varieties grown under conventional and MEY systems.

	No irrigation		With irrigation	
	Conven-tional	MEY	Conven-tional	MEY
	bu/A			
Top variety	44.8	51.7	55.8	59.3
Avg. 5 varieties	44.2	46.4	54.6	55.9
Bottom variety	39.8	43.2	54.0	55.0

cropped soybeans by fertilizing the preceding wheat crop. Several fertility practices are being studied in the MEY system to be sure that fertility is not a limiting factor. One variable is direct fertilization of the soybeans. Results to date, where high soil test levels for P and K are maintained, show that farmers have the option of applying the total two-crop P and K requirement to the wheat.

Research in New Jersey, Georgia and Ohio has shown that soybeans respond to N applied at pod-filling when yield potential is high. Our best yields have been obtained when N has been applied. But those yields are not always significantly better than the control plots. We will continue to experiment with N applications on soybeans.

The "3-Crop/2-Year" System

Our research is beginning to show that significant yield increases of all three crops in the system can be achieved with supplemental water, enhanced fertility and appropriate variety selection. Continued research is needed to fine tune the timing, rate and efficiency of the various inputs being utilized. We believe that developing new crop production practices through a "systems approach" has real merit. The high level of farmer interest in this research during field days at the Poplar Hill Research Facility supports this conclusion. ■

Economics of Long-Term vs. Short-Term Soil Fertility Management

By Harold F. Reetz, Jr. and Paul E. Fixen

Crop fertility programs should be developed as long-term strategic plans. Unfortunately, economics, land tenure arrangements, and other factors sometimes preclude long-term planning. However, the relative merits of a long-term fertility plan must always be compared with the limitations of a short-term plan.

CROP PRODUCTION is filled with uncertainties in the short-run. Weather conditions, crop prices, input prices, and pest problems vary from year to year, causing profitability to vary as well. Focusing on the uncertainties of annual yield and profit variability translates to overly conservative management decisions that decrease efficiency and limit profit potential.

Short-term fertility management, focusing on the next season's needs and potential response alone, can be a costly strategy. Farm operators with short-term plans find it difficult to commit to the investment of building soil fertility levels. Under the best conditions for uptake, less than 30 percent of the phosphorus (P) and less than 60 percent of the potassium (K) fertilizer applied is recovered and removed by grain crops during the first crop year after application . . . the rest remaining (in most soils) in available forms for future crops. It is difficult to justify the cost of buildup fertilizer in annual budget analysis. Yet, when **amortized** over a period of years, fertilizer costs necessary to build soil test levels to the higher productivity range are relatively **inexpensive.**

Consider Goals

The interests of the landowner and the tenant may not be the same when it comes to building fertility levels. Land tenure arrangements often discourage buildup fertility from the operator's point of view. When a farm is operated on a year-to-year cash rent basis, or other short-tenure arrangement, it is difficult for the tenant to justify expenditures for buildup fertilizer application. In fact, if he knows he has limited tenure, it may be to his advantage to hold back on maintenance applications –and to deplete the fertility resources in the soil. The landowner's interests, on the other hand, are best served by building fertility to the optimum soil test level and maintaining it with a sound fertility management plan. To protect both interests, the lease agreement might include details on cost sharing of buildup and maintenance fertilizer applications, such as specific guidelines for soil testing and record keeping.

It is in the landowner's best interest to share in–or even pay for–the costs of buildup fertilizer applications. In a crop-share lease, the landowner will benefit at least as much as the tenant from the higher fertility level. In a cash-rent situation, building soil fertility will result in a more productive farm that will often command a higher cash rent price. Higher yields generate more crop residue which helps improve soil tilth, maximize water and nutrient use efficiency and generally improve the value of the land. Well fertilized farms attract better tenants and help keep them on the land.

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Table 1. Impact of land tenure on net income to fertilizer K at a yield potential of 175 bu/A and initial soil test of 188 lb/A.

		Yield				Net income above buildup fertilizer cost	
Tenure, years	Optional soil test,[1] lb/A	Relative %	Absolute bu/A	Crop[2] value $/A	Amortized buildup cost[3] $/A	1 Acre	400 A
						----------$----------	
1	188	90.3	158	395	–	–	–
2	240	94.9	166	415	14.56	5.00	2,000
5	302	97.7	171	428	14.82	18.00	7,200
10	341	98.6	173	433	12.24	25.00	10,000

[1]Calculated as the soil test level at which the last increment of soil test increase is just paid for by the expected increase in yield. U. of Illinois K response curve: % yield=100x [1−10^(−.0054xK soil test)].
[2]Market value ($2.54/bu)−maintenance cost ($0.04/bu)=$2.50/bu.
[3](Optimum soil test level−188) x 4 lb K_2O/lb K test x $0.12/lb K_2O amortized over the land tenure period at 10% interest.

Buildup Fertilizer: A *Capital* Investment

Most farmers and landowners consider fertilizer to be an annual crop input investment. But **buildup** fertilizer applications should be treated as a **capital investment** to be amortized over a period of years. For a soil testing in the medium range for P or K, the cost of buildup to the high range will frequently be recovered within the first 2 or 3 years. If the cost is amortized over 5 or more years as a capital investment, it becomes a minor cost on an annual basis, yet the benefits continue to accrue each year the field is farmed. For a landowner who intends to maintain ownership for 5 years or more, there is a strong economic incentive to build soil tests rapidly, and to insist that they be maintained at an optimum level. Tenants who know they will be farming a field for several years also have a strong incentive to build fertility and maintain it at optimum levels.

Both the landowner and the tenant benefit from optimum fertility by being able to produce consistently higher yields, by being able to take full advantage of the above-average growing seasons, and by being less susceptible to yield losses in stress years. For forage crops, optimum fertility may also increase profits by increasing forage quality and stand longevity. Building soil fertility is a costly management decision, but **NOT** building soil fertility may be even more costly in terms of lost yield potential in an average year, increased yield losses in a poor year, and missed profit opportunities in the good years. Building fertility also may help reduce the risk of soil erosion, reduce costs of pest management programs, and maintain the productivity and value of the land.

Emphasis on Profit

Table 1 illustrates the importance of land tenure in determining the optimum soil test K level. Short-tenure leads to short-term management strategies which eventually reduce profitability. As land tenure period increases, the optimum soil-test K level also increases because more years of crops are affected by the elevated soil test level and the cost of the buildup may be amortized over more years.

Short-term strategies result in lower yields and generate less profit. For a 400 acre farm, the 5-year strategy generated over $7,000 extra income per year when compared to a one-year strategy. Expanding the tenure period from 2 years to 5 years increased net income by over $5,000 per year. **Short-term management strategies may be very costly!**

Building to and maintaining optimum soil test levels associated with long-term management strategies offer several additional benefits:

- Increased yield and income stability through a decrease in negative effects of too much or too little water.
- Reduction in yield loss from compaction.

- Greater flexibility in P or K use in individual years as prices and cash flow fluctuate.

- Greater flexibility in fertilizer placement (**Table 2**).

Table 2. Greater flexibility in fertilizer placement occurs at higher soil test levels.

Placement method	Yield, bu/A Low fertility	High fertility
No P or K	77	145
Broadcast	109	151
Surface band	103	153
Subsurface band	116	154

Chisel system; average of two years. Minnesota

- Increased potential for success in conservation tillage programs that improve soil productivity through long-term improvements in soil structure, organic matter, water-holding capacity, general tilth, etc. (**Table 3**).

Table 3. Adequate K is critical in conservation tillage systems, especially with some corn hybrids.

K_2O rate, lb/A	Hybrid A	Yield, bu/A Hybrid B	Hybrid C
0	144	165	143
40	152	175	159
80	153	175	165
160	152	175	162
Response	8	10	19

Soil test K=290 lb/A (high) Minnesota

- Increased rate of plant development leading to drier grain at harvest time.

- Lower grain moisture at harvest time (**Table 4**).

Table 4. Corn grain moisture is frequently lower at harvest with higher soil test levels.

Soil test P, lb/A	Corn grain yield, bu/A	Grain moisture, %
34	144	29.4
62	143	26.8
74	154	24.9
129	153	22.8

Wisconsin

- Greater long-term nitrogen (N) use efficiency, especially from improved uptake during stress years (**Table 5**).

Table 5. Potassium fertilizer rate increases N use efficiency; raises optimum N rate.

K_2O rate, lb/A	Corn yield (bu/A) at various N rates (lb/A) 0	60	120	180	240
0	49	63	77	77	61
40	60	81	88	115	112
80	55	82	110	120	125
120	41	83	118	135	152

Based on Illinois data.

Sharing the Benefits

The residual value of P and K fertilization makes short-term planning a costly practice. While the short-term tenant who invests in building fertility might be making a land improvement that will benefit someone else, the tenant may also increase the chances of renewing his lease by improving productivity. On the other hand, the tenant who allows soil tests to become depleted is limiting his profit potential even in the short term. The tenant, the landowner, and other interested parties will share in the benefits of improved fertility, not only in the short-term, but as long as the land stays in production.

Tools Adapted to the Long-Term

Soil testing and buildup and maintenance application strategies work best with a minimum of 5 years in the plan. The variability of soils and the lack of precision in sample collection and fertilizer application systems make conclusions drawn in the short-term very risky. For the farmer who is in financial trouble, there may be no alternative to short-term management. Unfortunately, farmers forced to think short-term are often those who can least afford to do so.

Long-term management plans including long-term soil tests and records of fertilizer use and crop yields are essential tools for making use of new variable-rate fertilizer application systems. Without the detailed soil tests and records, a farmer cannot take full advantage of this technology. With this information available, the variable-rate approach can mean further savings and increased profits.

Computerized mapping and application systems are not necessary to take advantage of variable-rate fertilization. They help make the job easier, but conventional systems can be used to fertilize different parts of a field with different rates and get many of the benefits. Site-specific management will become more common in the next few years as economic and environmental concerns continue to be an important force in management decisions.

The time and expense of site-specific management make it essential that it be a part of a long-term strategy. The farmer, landowner, dealer, and other advisers must make the commitment to follow the plan. All of their interests will best be served with a long-term plan.

Business Opportunity

Helping farmers and landowners work out long-term fertility management strategies can be a business opportunity for fertilizer dealers or crop consultants. It is usually part of their business to help work out fertilizer recommendations, but not always on a long-term basis. Projecting the costs and returns over a period of years –both in terms of agronomics and economics–is helpful in strengthening customer commitment and loyalty to the dealer. It is important to emphasize the value to customers of a long-term plan. They can use it to project expenses and income over time and work out the most acceptable program for building soil tests in fields needing improvement.

Environmental Benefits

Farmers, landowners, fertilizer dealers, and everyone else involved in fertilizer management decisions must consider the environmental impact of their recommendations and actions. There is an unfortunate perception that the environment can best be served by cutting back on fertilizer use. **That is not necessarily true!** When soil test levels are not adequate to support optimum crop growth and yields, soil losses are likely to be higher. Optimum P and K levels help to improve N use efficiency, reducing potential for nitrate movement into surface and groundwater. Higher yields from optimum fertility allow more options for removing less productive, more erosive fields from production and yet maintaining the same overall crop output.

Summary

Long-term management strategies for soil fertility are important for protecting the interests of both landowners and tenants. Building and maintaining soil test levels high enough to ensure optimum productivity will produce highest yields and greatest profits over time. Amortizing buildup costs as a capital investment over a period of 3 to 5 years can help justify the economics, because the benefits of the buildup will continue to accrue beyond that amortization period. Developing a long-term fertility management strategy helps maintain customer loyalty.

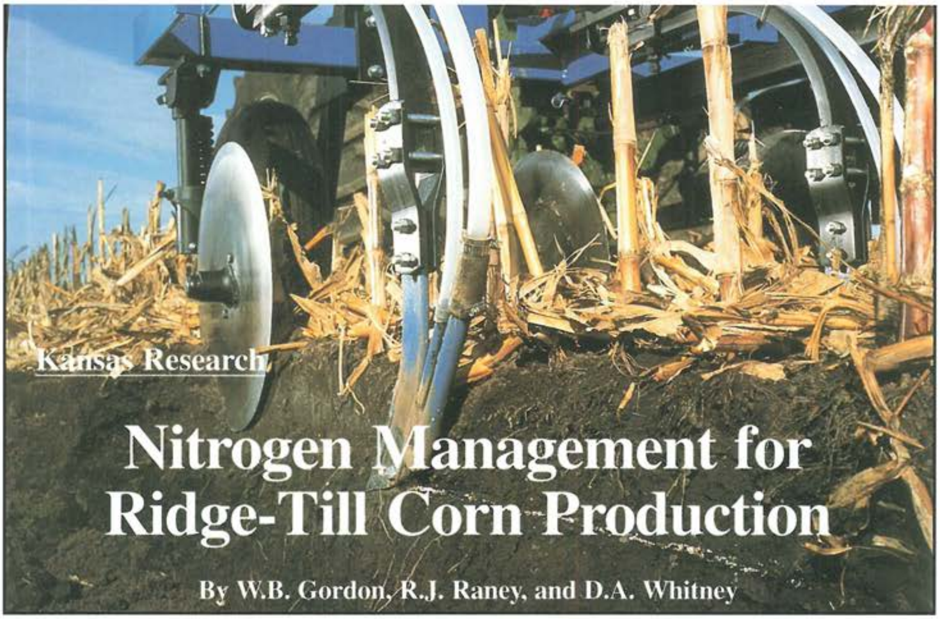
Long-term plans for optimum fertility also protect the environment through better N use efficiency, better soil tilth and improved erosion control. Sound fertility management pays big dividends to the farmer, the landowner, the dealer, and the environment. ■

New Publication Examines Spring Wheat Cropping Systems

GROWERS of spring wheat will find extensive information to help refine their crop input decisions in a new publication just released by the North Dakota State University Extension Service. Dr. Ed Vasey, Extension soils specialist, served as senior editor of the publication, titled *A Closer Look at the Spring Wheat Cropping System for More Efficient Yield (MEY) and Sustainability,* EB no. 58.

The guide is about 100 pages, with 48 illustrations in color. The 30 major headings in the publication range from developmental stages of the wheat plant to summaries for increasing profits in various yield ranges. There are also lists of additional resource readings and computer software support items.

The bulletin is available from Extension Distribution Center, NDSU, Box 5655, Fargo, ND 58105; cost is $5.00 plus $2.00 shipping and handling. ■



Kansas Research

Nitrogen Management for Ridge-Till Corn Production

By W.B. Gordon, R.J. Raney, and D.A. Whitney

While ridge-tillage has become a popular and effective practice for corn production, it poses some challenges in residue management and nitrogen (N) application. Research is answering some of the questions involved with this soil-conserving method.

MORE NOW THAN EVER, conservation tillage practices, including ridge-tillage, are being integrated into farming systems. This is due primarily to their effectiveness in conserving soil and water as well as their relationship to government programs. Ridge-tillage involves planting on a raised bed formed by cultivation from a previous growing season. Tillage is confined to a narrow strip on top of the ridge. This leaves large amounts of residue on the soil surface which can interact with N application methods and N fertilizers, causing immobilization, denitrification, and/or volatilization of N.

Design

This furrow-irrigated corn study was designed to assess the effectiveness of N rates (0, 50, 100, 200 lb/A N) and application methods of two N sources—anhydrous ammonia (AA) and 28 percent urea-ammonium nitrate solution (UAN), under ridge-till conditions.

Knifed AA and 28 percent UAN were applied 6 inches below the soil surface and midway between the old corn rows. Broadcast UAN was applied to the soil surface with flat fan nozzles. Dribble UAN treatments were applied at the base of the ridge on 30 inch centers. Split applications were applied half preplant and half when the corn was 12 to 15 inches high. Corn was planted at 25,500 seeds/A, using a Buffalo-Till planter with 10-inch sweeps for ridge clearing. Furrow irrigation totaled approximately 12 inches/year.

Results

When averaged over a 5-year period, corn grain yields were significantly higher for the preplant knifed AA and UAN

Table 1. Nitrogen application methods affected corn grain yield, 1987-1991.

Application method	5-year avg.,[1] bu/A
AA Preplant - Knifed	157 a
UAN Preplant - Broadcast	143 b
UAN Preplant - Knifed	156 a
UAN Preplant - Dribbled	145 b
UAN Split - Knifed	155 ab
UAN Split - Dribbled	150 ab

[1]Means followed by the same letter are not significantly different at the 5% level of probability.

Dr. Gordon is Superintendent, Irrigation Experiment Field, Courtland, KS; Mr. Raney is former Superintendent, Irrigation Experiment Field, Courtland KS; and Dr. Whitney is Agronomy Extension Leader, Kansas State University, Manhattan.

Table 2. Methods of N application had similar effects on grain N concentration and estimated total N uptake.

Application method	Grain N[1], %	Estimated total N uptake in grain, lb/A
AA Preplant - Knifed	1.39 a	127
UAN Preplant - Broadcast	1.33 b	110
UAN Preplant - Knifed	1.39 a	126
UAN Preplant - Dribbled	1.33 b	112
UAN Split - Knifed	1.39 a	125
UAN Split - Dribbled	1.37 a	119

[1]Means followed by the same letter are not different at the 5% level of probability.

applications (**Table 1**). Broadcast and dribble applications of UAN produced significantly lower yields. Dribble and broadcast UAN applications were essentially equal. Split applications of UAN knifed and dribbled were no better than applying all of the N preplant by these methods.

Preplant broadcast UAN was as effective as knifed UAN in only one of the five years of this study. Ammonia volatilization losses or residue immobilization of N during that year may have been minimized by a half-inch rainfall shortly after N application.

When averaged over all application methods and years, maximum grain yield was achieved with 153 lb/A of fertilizer N (**Figure 1**).

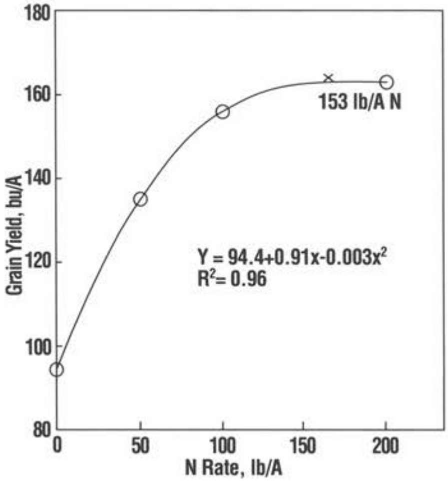


Figure 1. Corn grain yield as affected by applied N (avg. over application methods), 1987-1991. (Kansas)

Applying more N did not compensate for inefficient application methods.

Grain N concentration followed the same trends as grain yields (**Table 2**). Generally, preplant broadcast and dribble UAN produced significantly lower grain N concentrations. Knifed N applications resulted in a higher total N removal in the grain than other application methods. This is important environmentally, since an additional 10 to 15 lb/A N was removed in the grain, lowering residual soil nitrates.

Summary

Selection of N source and application method is an important management consideration in reduced tillage production systems. For ridge-till corn on this fine-textured soil:

- Knifing UAN produced higher grain yields and grain N concentrations than surface broadcasting or dribbling.
- Knifed UAN and AA produced about 13 bu/A higher yields than broadcast UAN.
- Dribbled UAN was essentially equal to broadcast applications.
- Split applications of knifed UAN did not improve yields or grain N concentrations over similar application of preplant N.
- Regardless of application system, maximum grain yield was achieved with 153 lb/A N.
- Knifed AA and UAN treatments had equal effects on grain yield or grain N concentration. ■

Corn Populations for the Northern Corn Belt

By D.R. Hicks

Crop production systems are extremely interactive. We must continually watch for needed refinements induced by subtle changes in genetics and standard management practices. This article indicates that many corn producers may need to reevaluate the plant populations they're using in today's higher yield potential systems.

EVEN THOUGH corn populations have increased during the past few years, higher economic yields can be obtained with higher plant populations in the upper Corn Belt. In Minnesota, the average plant population is about 24,000 plants per acre (ppa). The economic **optimum** harvest population is about 28 to 30,000 ppa.

Several factors affect the optimum plant population: the hybrid, maturity of the hybrid, management practices, and soil type. Growers should begin thinking of a final stand of 28 to 30,000 ppa; this would require a seeding rate of 31 to 33,000 viable kernels per acre. This population should be considered the optimum for today's hybrids grown under good management conditions and should be adjusted upward or downward depending on the factors discussed here.

Hybrid

After corn farmers have chosen the hybrid(s) they intend to grow, they should ask the dealer or company agronomist for a population recommendation for that hybrid(s). Companies have tested the hybrids under many different environments and can give precise population recommendations for each hybrid.

Farmers should give a "lot of weight" to the recommendation of the company for a particular hybrid, but they should challenge the hybrid if the recommended population is appreciably below the range of 28 to 30,000 ppa.

Hybrid Maturity

The target population of 28 to 30,000 ppa is for full season hybrids. Hybrids that are less than full season for a growing zone will generally require higher populations to reach their yield potential. Harvest populations should be increased 1,000 ppa for every five (5) relative maturity (RM) units earlier. For example, if a grower considers 100 RM to be "full season" for his/her farm and wants to plant a 95 RM hybrid, the target population should be 29 to 31,000 ppa.

Management Practices

When management practices other than plant population are limiting yield, the target population can be reduced below the 28 to 30,000 level without reducing yield. One cannot expect a yield response to higher plant populations if fertility (any nutrient) is limiting, or if weed control is poor, or the crop is planted too late (after May 10). Under these conditions, maximum yield has been predetermined and a yield response to higher populations, particularly an economic one, is less likely to occur.

Soil Type

Soil type affects water holding capacity; coarse textured soils cannot hold as much available water. In areas with limited rainfall or coarse textured soils, one can reduce the target population to 24 to 26,000 ppa.

Dr. Hicks is Professor and Extension Agronomist, University of Minnesota.

Research Results

Corn grain yields for a population trial conducted at the Southwest Experiment Station at Lamberton, MN are presented in **Figure 1**. The trial was conducted from 1984 through 1989; the experiment was abandoned in 1987 because of a prolonged early season drought. Rainfall was higher than normal for all other years, except 1988, which was a very dry year. The upper line in **Figure 1** is the 5-year yield average (including the dry year of 1988) and the lower line is the 1988 dry year results. For the 5-year average, grain yields continued to increase with increased plant populations up to 40,000 ppa.

These results were surprising and caused us to follow with more plant population trials at other locations and with more corn hybrids. Results of those trials are given in **Figure 2** for each location, averaged across six hybrids at each location. The hybrids were the same at Rosemount, Waseca, and Lamberton locations. The response to plant population was not as pronounced as in the earlier trials at Lamberton. Highest yields were produced with harvest populations of 28 to 33,000 ppa for all six hybrids, at all four locations.

There's always the concern about "what happens in dry years with high plant populations?" The yield response in the dry year 1988 at Lamberton is the lower line in **Figure 1**. Yields increased similar to that in other years with more rainfall. Yields were limited because of dry weather at Morris in both 1990 and 1991 (**Figure 2**). There was very little effect of population on grain yield, but more importantly **yields did not decline appreciably**, even at very high populations. This response is typical in dry years with today's hybrids.

Growers need to ask themselves if they are pushing corn plant population to reach maximum economic yields? They may not be if harvest populations are below 28,000 ppa. With good management programs using early planting, good weed control, optimum fertility, and proper hybrid selection, corn harvest populations should be in the 28 to 30,000 ppa range for maximum profitable corn yields in the northern Corn Belt. ■

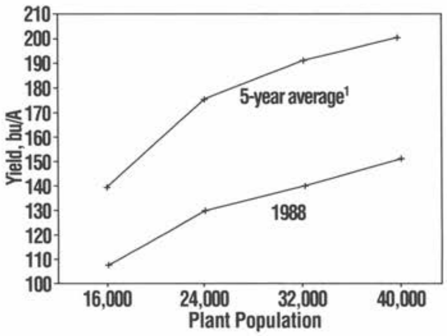


Figure 1. Corn grain yield as affected by plant population at Lamberton, MN, 1984-89. Years 1984 through 1989 (except 1987).

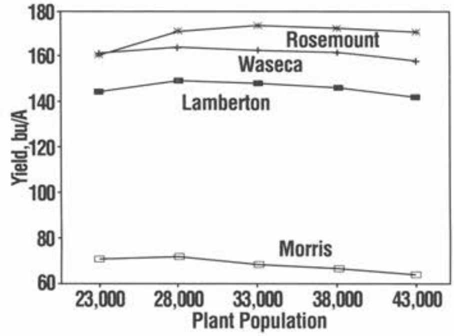


Figure 2. Corn grain yield as affected by plant population at four locations in Minnesota, 1990-91.

Research in Israel

Foliar Feeding of Potassium Nitrate in Cotton

By U. Kafkafi

In high-yielding cotton varieties, more than three-fourths of the potassium (K) can be partitioned to fruiting structures (bolls). When K is limiting late in the season, foliar deficiency symptoms develop which are not typical. They occur on young leaves rather than older leaves. This study reinforces the contention that, under limiting soil conditions, foliar application of K during boll fill can supplement the K demand of the developing boll.

RECENT WORK in Arkansas has demonstrated the beneficial effect of foliar feeding of potassium nitrate (KNO_3) in cotton. California research has shown that cotton grown on vermiculitic soils exhibits K deficiency symptoms during periods of high demand for K transport to the developing boll.

The dominance of fruiting structures as a sink for K is well known. Plants of high-yielding varieties have been shown to partition as much as 78 percent of total plant K to fruiting structures. Acala varieties had only 60 to 65 percent of total plant K in fruiting structures at an equivalent stage of development.

Economic yields of cotton depend on optimal fiber growth. Potassium has a key role in fiber quality and is the most abundant mineral nutrient in fibers. With the cotton plant sensitivity to K shortages, several anomalies are associated with the occurrence of late season K deficiencies.

- Foliar symptoms are not typical of K deficiency and appear first on young, rather than old leaves.
- Soil test values do not always accurately reflect availability of soil K to cotton.
- Soil application of up to 700 lb/A K_2O does not eliminate foliar K deficiency symptoms in severely affected fields in California. Late-season K deficiencies have been estimated to limit lint yield on over 200,000 acres, about one-fifth of the cotton acreage in the San Joaquin Valley.

In irrigated, high-yield cotton, maximum K uptake rates range from about 3 to 5 lb of K/A per day. Potassium is a relatively immobile ion in soil. Its movement to plant roots depends mostly on diffusion. The rate of K uptake is dependent on root length, density, and total root surface area. Cotton is distinguished by its low density root system, further complicating K uptake.

Potassium Absorption by Cotton Foliage

The capability of cotton leaves to absorb foliar applied nutrients is limited because of the cuticle barrier. It is impossible, as trials have shown, to feed plants solely via the leaves and to bring them to full development and adequate fruit formation. However, foliar fertilization can be used to satisfy acute needs for supplemental nutrients.

Factors affecting foliar absorption of nutrients include: leaf age, relative position of "source leaf" to bolls, nutritional status of the plant, and certain environmental factors.

In these investigations of foliar absorption, a short-lived radioisotope ^{42}K (half

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Figure 1. Radioactive $^{42}KNO_3$ was applied as a solution along the midrib of the cotton leaf.

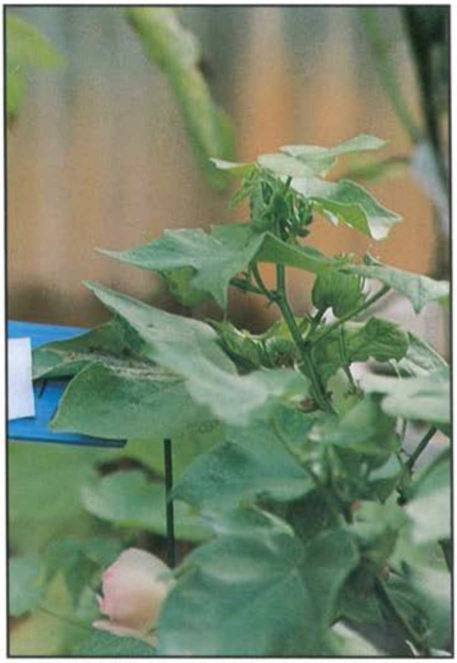

Figure 2. The experiment included boll-bearing plants (above) as well as young plants.

life of 12.4 hours) was utilized and its uptake and movement to the sinks of the developing boll and other plant parts followed. Radioactive $^{42}KNO_3$ was prepared by dissolving potassium carbonate ($^{42}K_2CO_3$) in dilute nitric acid (HNO_3) and applying the solution by micro pipette along the mid rib of the cotton leaf (**Figure 1**).

Twenty hours after foliar application, the treated leaf was removed to prevent high background activity. The radioactivity in other plant parts was recorded by a portable detector. The treatments were conducted on boll-bearing plants (**Figure 2**) as well as on young plants. The activity found in the plant parts demonstrated that ^{42}K is penetrating the leaf cuticle and is transported from the leaf to the young developing tissue.

The plant parts that demonstrated the highest activity are described in **Table 1**. High activity levels were found in the developing tip and developing bolls. The transport of K from the leaf to other organs was occurring within 20 hours of application, emphasizing that the developing organs are a strong sink for K from the leaf. These data reinforce the conclusion that when the soil K supply is limited, foliar spray of K during the boll-filling period can supplement the heavy demand of the developing boll. ■

Table 1. Radioactivity in plant parts 20 hours after ^{42}K applications to the young mature leaf.

Plant number	Boll	Leaf	Tip	Tip leaf
	(cpm)			
4	11,500	40,000	—	—
5	20,000	—	10,000	—
7	10,000	—	2,000	—
8	800,000	115,000	250,000	—
9	19,000	150,000	18,000	15,000

A Closer Look at Corn Nutrient Demand

By Alan Olness and G.R. Benoit

Fertility management programs for today's high yielding crops must satisfy nutrient requirements at all stages of the growing season. Recent research has helped clarify nutrient accumulation patterns and relationships for corn.

GETTING THE MOST out of fertilizer investment requires matching plant nutrient demand with soil nutrient supply. While benefits of fertilization have been recognized for centuries, scientists have only recently begun to take a closer look at relative rates and times of nutrient availability and accumulation. Early studies of nutrient uptake by corn were concerned more with total uptake than with relative rates and periods of uptake.

Corn has **two** intense periods of nutrient uptake. The first uptake period occurs during vegetative growth; the second during reproductive growth or ear development (**Figure 1**). Potassium (K) uptake shows a different pattern from that of nitrogen (N) and phosphorus (P). Net K uptake seems restricted mainly to the vegetative growth period. Usually, uptake rates for N, P and K are much less during tasseling and silking than during the two growth periods.

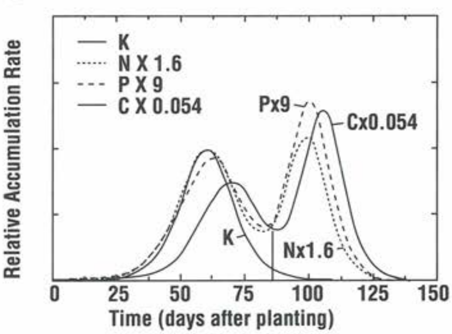

Figure 1. Accumulation of N, P, K and carbon (C) by corn planted in early May in Minnesota. The vertical line represents the date of 50% tasseling and silking. The amount of N accumulated was multiplied by 1.6, P by 9 and C by 0.054 so that the uptake could be shown on the same graph.

During vegetative growth, N and K are synchronized both in time and amount of uptake (**Figure 2**). The amount of N accumulated ranges from about 0.55 to 0.85 times the amount of K accumulated during leaf and stalk development. The close relationship between N and K accumulation is probably related to ammonium-N (NH_4^+-N) uptake. Corn takes up N in both nitrate-N (NO_3^--N) and NH_4^+-N forms.

The form in which N is accumulated requires adjustment for ionic charge both within the plant and externally to the root. Uptake of NH_4^+-N tends to acidify the root environment and inhibit K ion (K^+) accumulation. As a result, today's corn hybrids seem to grow best when the ratio of NO_3^--N to NH_4^+-N is about 2 to 3. At these ratios, K^+ uptake is capable of balancing some of the charge of NO_3^--N and the rest

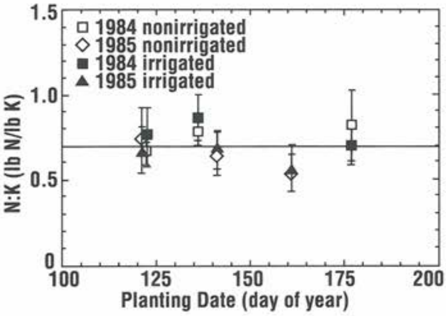

Figure 2. Relative amounts of N and K uptake by corn planted at different dates.

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can be balanced by NH_4^+-N uptake. While corn accommodates different ratios of N forms and availabilities of K, it seems to do so by sacrificing growth and grain yield potentials. Thus, balances in forms and amounts of N with K are important for optimal growth during the vegetative stage. Some loss of K from leaves and stalk during grain filling occurs, but the exact reason for this loss is unknown.

Regardless of planting date or climatic condition, the maximal vegetative accumulation rate for both N and K occurs at the same time (**Figure 3**). At maximal

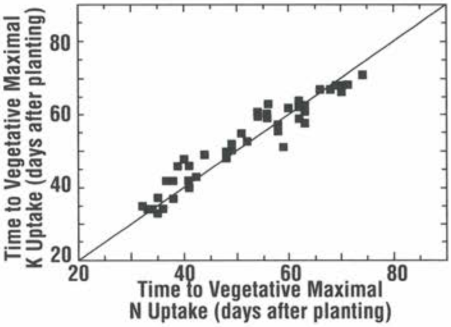

Figure 3. Time of maximal uptake rate for N and K during vegetative growth. The diagonal line represents a perfect relationship.

rates of accumulation, a stand density of 25,000 plants per acre can remove about 1.9 to 4.2 lb of N and 3.4 to 4.9 lb of K each day. These rates vary and are strongly affected by soil temperature. Soil temperature affects the rate of root growth which, in turn, affects the volume of soil accessed by roots.

As planting date is delayed, soil and air temperatures increase and the warmer environment causes growth to accelerate. The increased growth rate creates an increased demand for nutrients. Time required to reach maximal uptake rates for N and K shortens as planting date is delayed (**Figure 4** vs. **Figure 1**). When this happens, daily amounts of N and K removed from the soil increase but the period of uptake shortens. Under these conditions nutrient management becomes even more important.

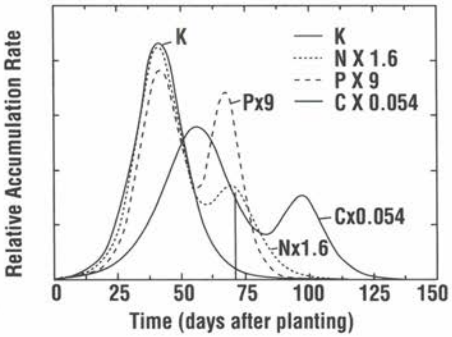

Figure 4. The effect of delayed planting on the time and relative rate of nutrient uptake by corn. This corn was planted in late May on a Hamerly clay loam. The vertical line represents 50% tasseling and silking.

Accumulation of P is critical for transforming, storing and moving energy in the plant; so it is no surprise that corn growth is closely related to the amount of P accumulated in each stage. Corn clearly shows a two-stage pattern of P uptake. During vegetative growth, the maximal rate of P accumulation usually occurs about 3 days after that of N and K. When planting is delayed later than early May, P uptake during grain fill decreases and grain yield declines (**Figure 5**).

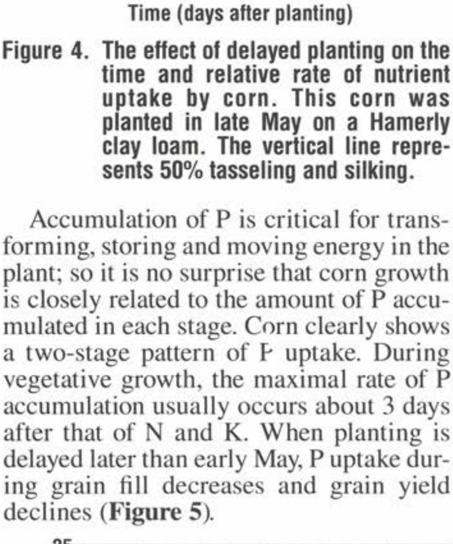

Figure 5. The change in uptake of P during grain fill as a function of planting date.

In a recent study in Minnesota, P uptake averaged about 12.7 lb/A before tasseling and about 13.0 lb/A during grain fill; grain yields averaged about 150 bu/A. For every day planting was delayed, P uptake during grain fill decreased at the rate of about 0.12 lb/A and grain yield decreased by about 2.3 bu/A.

(continued on next page)

Nutrient Demand . . . from page 19

Summary

Corn takes up nutrients in a well defined pattern. Nitrogen and K are accumulated synchronously during vegetative growth. Net accumulation of K ceases at or near tasseling. Maximum rates of P accumulation occur about 3 days after those of N during the vegetative period. A close relationship exists between N and P uptake during reproductive growth and grain fill. Both N and P accumulation rates peak once during vegetative growth and a second time during grain fill. Soil fertility must be managed to satisfy both peak demands to realize full yield potential. ■

Missouri

Phosphate Interaction with Uptake and Leaf Concentration of Magnesium, Calcium and Potassium in Winter Wheat Seedlings

LOW tissue concentrations of magnesium (Mg) and calcium (Ca) in cool-season grasses in late fall and early spring are primary causes of grass tetany and wheat pasture poisoning in grazing cattle. The objective of this study was to determine the interaction between phosphate and leaf concentrations of Mg, Ca and potassium (K) in winter wheat.

Seedlings were grown hydroponically or in perlite with nutrient solution concentrations similar to those found in a typical midwestern Alfisol. As solution phosphorus (P) was increased, Mg and Ca concentrations in the leaf increased while K decreased. The K/(Ca + Mg) ratios were lowered from 1.8 to 1.0 in one greenhouse study; from 1.7 to 1.2 in another. ■

Source: T. M. Reinbott and D. G. Blevins. 1991. Agron. J. 83:1043-1046.

Preplant Manure Applications for Alfalfa Production

By M.A. Schmitt, C.C. Sheaffer, and G.W. Randall

Proper management of manure is critical in regions with large livestock numbers if water quality is to be preserved. Frequently, livestock producers apply manure to alfalfa when corn ground is not available. The following research results evaluate the agronomic and environmental soundness of this practice.

LIVESTOCK PRODUCERS often find themselves in a dilemma when they do not have enough corn acres for spreading their manure at agronomic rates. This leads to the need for additional acres to spread manure, and for dairy farmers, alfalfa is often the only other crop grown.

A long-term project was started in 1989 to examine the effects of preplant manure fertilization on alfalfa. Trials were established at University of Minnesota Agricultural Experiment Stations at Rosemount and Waseca. Ammonium acetate extractable soil potassium (K) was 200 parts per million (ppm) at the Rosemount sites and 94 ppm at Waseca. Soil Bray P-1 phosphorus (P) was 35 ppm and 8.5 ppm at Rosemount and Waseca, respectively.

Three rates of manure . . . 3,000, 6,000, and 12,000 gallons per acre (gpa) . . . were broadcast and incorporated prior to establishment of alfalfa, which was direct seeded. Swine manure was used at Rosemount and dairy manure at Waseca. Three commercial fertilizer treatments, consisting of potassium chloride (KCl) and triple superphosphate (TSP), were also used to give equivalent P and K application rates contained in the three rates of manure. A control treatment was included at all sites.

Various alfalfa yield and nutrient removal values were measured. In addition, inorganic nitrogen (N) was monitored in the soil throughout the study.

Results

At all sites, manure and fertilizer treatments resulted in dramatically higher yields than the control areas (data not shown). At the Rosemount sites, the manure treatments produced significantly higher yields than the corresponding fertilizer treatments.

Weed pressure was visibly increased with the manure application. However this difference was not statistically significant. After the first cutting, weed pressure was not visibly different among the treatments.

Alfalfa producers are vitally interested in production year yields. Expressed as a percent of the control plot yield (**Figure 1**) increasing manure rates resulted in increased yields at all sites. The increase was much more dramatic where soil P and K tests were low or medium. Responses to the fertilizer treatments were similar on the low testing soils–increased fertilizer rate resulted in increased yield.

At approximately comparable P and K rates, manure treatments generally outyielded plots receiving fertilizer only (**Figure 1**). On very high P and K testing

Dr. Schmitt is a soil scientist in the Department of Soil Science and Dr. Sheaffer is an agronomist in the Department of Agronomy and Plant Genetics, both at St. Paul, MN; Dr. Randall is a soil scientist at the Southern Experiment Station in Waseca, MN. All are with the University of Minnesota.

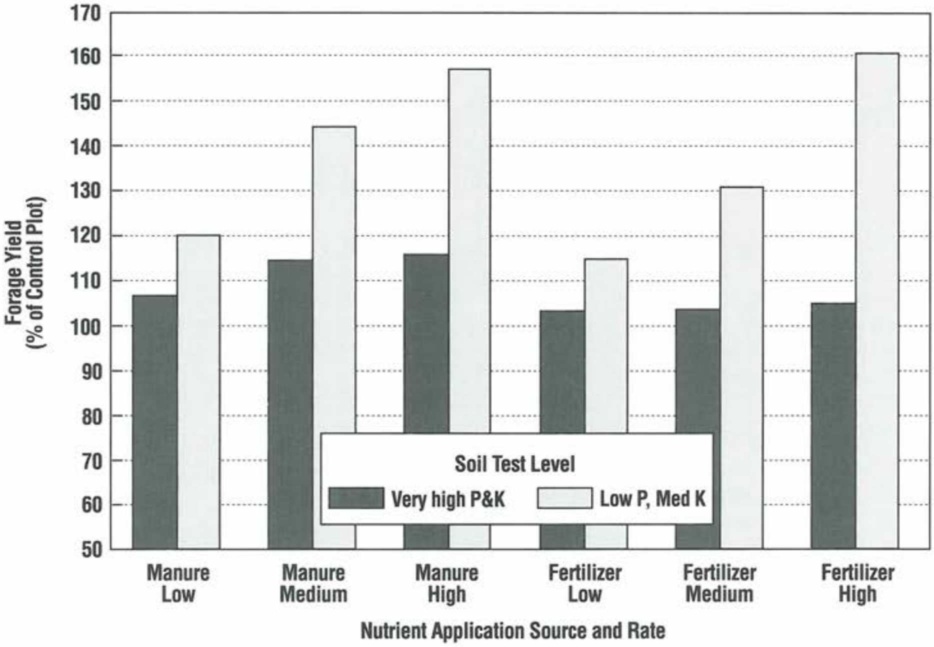

Figure 1. The effect of nutrient application sources and rates on production year forage yields.

soils where P and/or K fertilizer response would not be predicted, manure additions still improved yield. This implies that some other nutrient or property contributed by the manure was beneficial.

Plant N measured at each cutting did not vary with treatment. This is not surprising because alfalfa gets much of its N from the soil or atmosphere. Plant P concentrations from the first cuttings each year were not significantly affected by nutrient treatments (**Table 1**). Plant concentrations of K increased according to the rate of K applied in either nutrient source (**Table 1**).

Table 1. The effect of preplant nutrient applications on P and K concentrations in first cuttings each year for all sites.

Source	Rate	P	K
		----- %	-----
Control	—	0.29	1.70
Manure	Low	0.30	1.90
Manure	Medium	0.31	1.95
Manure	High	0.31	2.11
Fertilizer	Low	0.28	1.81
Fertilizer	Medium	0.28	1.88
Fertilizer	High	0.31	2.24

Nitrate N concentrations in the soil provide an indicator of the amount of N available from the manure. Soon after manure application, soil nitrate N concentrations were relatively high compared to the control plots (**Figure 2**). Five months after application, neither the 3,000 or 6,000 gpa treatments had resulted in significantly higher soil nitrate N than the controls. Soil nitrate N concentrations in the high manure rate treatment area continued to decline and were comparable to those in the control plots by the second year.

Summary

Either manure or inorganic fertilizer can supply the nutrient requirements of alfalfa. Both nutrient sources increased dry matter production, although manure-amended treatments inexplicably produced more dry matter than a comparable amount of P and K fertilizer. There was no difference between the two nutrient sources with regard to the N, P, and K composition of the forage.

Seedbed preparation is important for establishment of alfalfa. With preplant

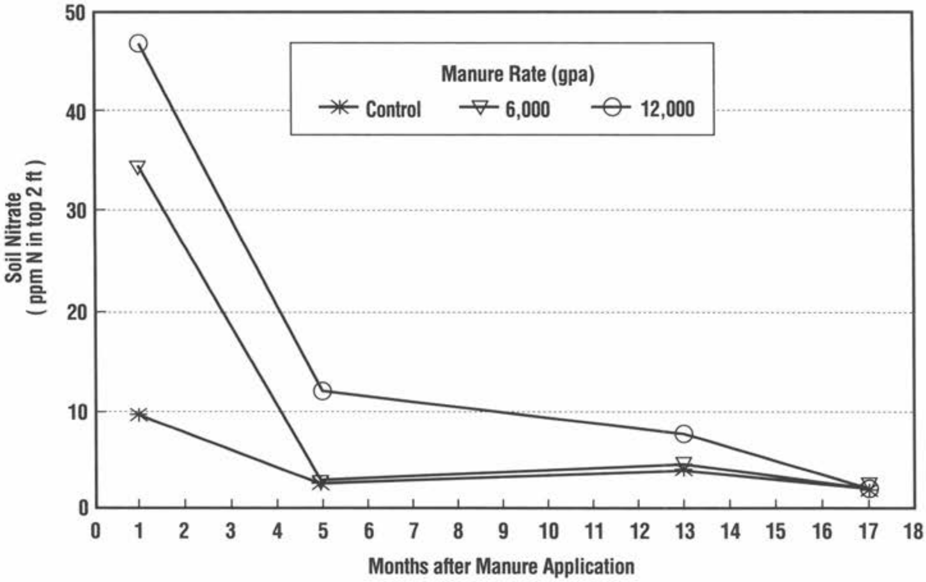

Figure 2. Soil nitrate-N concentrations in the top 2 feet of soil as affected by the rate of manure application and sampling time after application.

manure applications, the potential for having a poor seedbed is higher. Manure must be applied to the soil and thoroughly mixed into the topsoil. Otherwise, alfalfa may be seeded into high concentrations of manure and wheel traffic over the seedbed may cause excessive compaction, both reducing alfalfa stand uniformity. In the final analysis, with proper rate and distribution, alfalfa appears to be an acceptable alternative crop for manure application. ■

LUSH GROWTH of alfalfa in these plots occurred where manure was applied.

An Alfalfa Management Program for Optimum Yields and Quality

By Les Vough and Morris Decker

Research in Maryland is showing that alfalfa responds to precision management. Reaching higher yield goals requires a commitment to alfalfa management for 12 months of the year.

ALFALFA is well adapted to a wide range of climatic and soil conditions throughout Maryland. Today, average yields across the state are in the range of 3 to 4 tons/A. Yields double or triple these average values are consistently produced in research trials and by top growers.

The genetic potential for high yields is found in many of the available varieties. (**Table 1**).

Generally, alfalfa producers are aware of the many management decisions which must be considered in growing alfalfa. Producer meetings, farm magazines, dealer contacts, and the Maryland Cooperative Extension Service are main sources of information. But the producer's ability to package this information into a high yielding system specific for Maryland conditions frequently needs to be improved.

The four most common limiting factors in Maryland alfalfa production are:

Management Factor	Most Common Error
Fertilization practices	Underestimate potassium (K) requirements.
Harvest schedule	Late first cut.
Insect control	Not scouting and controlling leafhopper.
Timeliness	Not planning ahead to assure precision.

Fertilization Practices

The success or failure of high yield alfalfa depends to a large extent on fertilizer management. Alfalfa fertility research in Maryland over the past 6 to 8 years has confirmed the need to increase fertilizer rates over the practices being used by most producers in the state. Typical fertilizer practices today are to topdress alfalfa annually with 100 to 200 lb/A K_2O. Considering average K_2O removal is 65 lb/ton, more for 8 to 10 ton yields, it follows that average alfalfa yields in Maryland correspond to typical fertilization practices—many farmers are only fertilizing for 3 to 4 ton yields. This

Table 1. Maryland alfalfa variety trial yield summary, 6-year average (1984-1989).

Location	Yield, tons/A (12% moisture) Top five varieties	Bottom five varieties	All varieties	Number of varieties in test
Forage Research Farm	9.0	7.8	8.5	31
Wye Research Center	8.5	7.6	8.1	18

The authors are with the Department of Agronomy, University of Maryland.

Table 2. Alfalfa and alfalfa-grass mixtures respond to fertilizer treatments in Maryland (4-year avg. yields).

Total lb/A applied, 4-years		Yield, tons/A (12% moisture)			
P_2O_5	K_2O	Alfalfa alone	Alfalfa/ orchardgrass	Alfalfa/ timothy	Alfalfa/ fescue
60	460	6.3	6.3	7.0	7.2
80	1,087	7.6	8.2	8.0	8.0
243	2,197	8.6	9.0	8.8	9.8

Soil test levels: P_2O_5 = high; K_2O = med-high, at seeding.

Table 3. The relationship between K_2O applied and removed for a high yield alfalfa/orchardgrass mixture (4-year totals).

	Soil fertility levels		
	Lowest	Medium	Highest
Total 4-year yields, tons/A	25.2	32.8	36.0
K_2O, lb/ton removed[1]	55	60	65
K_2O removed, lb/A[1]	1,386	1,968	2,340
K_2O applied, total lb/A	460	1,087	2,197
K_2O drawdown, lb/A	926	881	143
K soil test:			
Fall 1984 (establishment year)	131	236	433
Spring 1990 (final harvest 1989)	52	114	450+

[1]Estimated from past research and Pennsylvania Alfalfa Growers Program.

high fertility demand of alfalfa was confirmed in a study completed in 1990. Four-year average yields are shown for pure alfalfa and three alfalfa-grass mixtures grown at three fertility levels (**Table 2**).

The amount of K_2O removed by the alfalfa-grass mixtures was estimated in this study. **Table 3** shows the tremendous soil K drawdown associated with alfalfa production. One reason that relatively good yields were maintained at the lower K_2O application rates is the high K release characteristics of this soil as indicated by soil test trends.

Maryland recommendations call for alfalfa to be grown in rotation. The benefits of maintaining alfalfa in a rotation with corn, especially when it is managed for top production, is shown in **Table 4**. No nitrogen (N), phosphorus (P) or K fertilizers were applied in this study during a 5th-year of forage harvest or to the following corn crop. The yield and economic benefits from the tremendous N carry-over and for maintaining high P and K fertility are apparent. Assuming a pound of N for a bushel of corn, the amount of N supplied by the previous alfalfa was over 190 lb/A from the high fertility plots. This is a higher figure than is usually credited for alfalfa in fertilizer recommendations for corn and represents an additional economic advantage of managing alfalfa for optimum production.

Table 4. Alfalfa and fertility residual effects on corn yields.

Fertility level	Alfalfa alone	Alfalfa/ orchardgrass	Alfalfa/ timothy	Alfalfa/ fescue
	------------- bu/A -------------			
Highest	193	194	183	179
Medium	197	173	176	174
Lowest	136	132	141	131

Based on these research results, a recommended alfalfa soil fertility program for yield potential of 8 to 10 tons/A in Maryland is:

- Soil test: Apply lime 12 to 18 months in advance of seeding so that soil pH is 6.8 to 7.0 at seeding. Soil test regularly throughout the life of the stand and maintain soil pH at 6.5 to 7.0.
- Broadcast P and K to bring soil test levels into the high range for the crop preceding alfalfa in rotation.
- Apply 15 lb P_2O_5, 65 lb K_2O, and 0.5 lb boron per ton of expected hay yield.

- Split topdressing applications, with half applied after the first harvest in May and half applied after the 4th harvest in August or early September.
- Monitor the fertilizer program with soil and plant analyses each year. Keep alert for possible sulphur (S) deficiencies.

Harvest Schedule

The date of first harvest sets the stage for the rest of the growing season. For top yields and quality, the first harvest of established alfalfa should be finished by May 20 in most areas of Maryland (**Table 5**). This means starting the first harvest at the early bud stage. Subsequent harvests should be approximately every 32 to 35 days. The last harvest period should be longer to allow food reserves to be stored in roots and crowns for nourishment of the plant over winter and a vigorous regrowth the next spring. Many of the alfalfa varieties available today can persist with a 5-cut system and produce 8 to 10 tons/A over the life of the stand, providing they are well-fertilized and protected from insect damage.

Maryland Alfalfa Management Project

To help Maryland alfalfa producers adopt management skills necessary for top alfalfa yields and quality, an Alfalfa Management Project is being initiated in Garrett County in western Maryland. There is no better way to get growers to accept a new management practice than to show them how it works on their own farms. Encouraging a respected local farmer to successfully use a new practice is a good way to get it adopted in the community. These two observations are basic to the formation of this first Alfalfa Management Project. The Project will provide a forum for a small group (20 members) of growers to meet periodically to learn precision alfalfa management from specialists, to put these practices into use on their own farms, and to learn from each other about the challenges of growing higher yielding, better quality, and more profitable alfalfa. Primary benefits to the project members are the personal satisfaction gained from being a better alfalfa producer...and the higher profitability of better yields and better quality.

Maryland Alfalfa Management Calendar

To help overcome a major limiting factor in good alfalfa production (planning ahead or timeliness), a 12-month Alfalfa Management Calendar has been developed for use with the Garrett County Alfalfa Management Project. This Calendar alerts farmers to the management decisions and actions which must be taken each month for both new seedings and established stands. The Calendar details the recommended production practice, or gives reference where the recommendation can be found. The Calendar will be updated each year to reflect new recommendations and Alfalfa Management Project activities for that year. An abbreviated August Calendar is shown as an example. ■

Table 5. Harvest schedule for established alfalfa-orchardgrass stands in Maryland.

Harvest number	Harvest dates, Piedmont and Coastal Plain	Days to next harvest	Harvest dates, Mountains	Days to next harvest
1st	May 5 to May 20	35	May 15 to May 30	42
2nd	Jun 9 to Jun 24	35	Jun 26 to Jul 11	42
3rd	Jul 14 to Jul 29	35	Aug 7 to Aug 22	64+ to 54+
4th	Aug 18 to Sep 2	63+ to 48+	After Oct 10-15	
5th	After Oct 20			

Maryland Alfalfa Management Calendar

(For Central and Southern Maryland and Eastern Shore)

AUGUST

Management Considerations

New Late Summer Seedings:

- Adequate lime and fertilizer applications must have been made to previous crops in rotation.
- Inoculate seed using sugar-water solution.
- Double check seeding equipment for proper seeding depth and rate.
- Apply starter fertilizer—15 to 20 lb N/A along with 20 to 40 lb P_2O_5/A is beneficial to establishment, especially if banding equipment is available.
- No-till into small grain stubble, Aug. 10 to Sept. 10.
- Apply second application of Gramoxone Extra immediately after seeding. First application would have been made 7 to 10 days after grain harvest or when weeds and volunteer grain had germinated.
- Monitor every 2 to 3 days for seedling emergence and development during the first two weeks after seeding. Then monitor weekly for weed, insect and disease problems.

Established Stand:

- Continue weekly monitoring schedule for potato leafhopper through mid-August.
- Fourth cutting. Record date that each field is cut.
- Take plant analysis sample to help monitor fertility program.
- Immediately after harvest, apply second half of estimated fertilizer requirements based on up-dated yield goals and soil fertility levels.
- Take stand counts.
- Scout for insect, disease or weak stand problem areas. Dig roots to help identify problems.
- Record observations on each field.

Alfalfa Management Project August Activities

- Hold an evening field meeting.
- Visit one or two members' high yield and test areas.
- Have in-field discussion time to share experiences.
- Special training on fall harvest management.
- Review late summer seeding techniques.
- Project members bring plant samples for analysis.
- Plan a family cook-out/picnic.

Continuous Grain Corn Production–Menace or Benefit?

By A.F. MacKenzie and B.C. Liang

Quebec research shows that high yields of continuous corn benefit soil quality. High corn yields primarily increased soil organic carbon levels. Results support earlier research findings.

CORN provides tremendous dry matter yields, rich sources of energy, protein, and minerals. Yet corn has been singled out as a soil-degrading crop that can cause environmental damage through loss of soil organic matter, resulting in increased soil erosion and reduced soil quality. Is there a possible way that corn could be managed to provide those immense benefits without excessive soil damage?

The benefits and risks with corn production can be phenomenal. It is estimated that each North American consumes about 3.5 lb (1.6 kg) of corn per day, directly, and in meat, dairy products, sweeteners, starch, and in miscellaneous uses such as packaging and plastic. Any idea of removing corn from our food system would be unreasonable.

Corn and Soil Organic Matter

Corn has been implicated in soil degradation in many studies. Continuous corn has been shown to decrease soil organic matter, or more specifically, soil carbon (C) and nitrogen (N). Soil organic matter is intimately associated with organic C and N. Often, the various forms are considered interchangeable. In this study, we used organic C and N as indicators of organic matter, without referring to the many complex forms found in the soil.

Soil organic C and organic N are dynamic materials. The amount of soil organic matter is a balance between the rates of addition of C and N in plant residue and rates of decomposition of organic materials. The effect, then, of a cropping system on soil organic matter is a balance between residues returned to the soil and microbial decomposition. This balance was dramatically shown by Larsen and coworkers where residue additions above 2.7 tons per acre (6 tonnes per hectare) resulted in net increases in soil organic C. Returning less than that amount of residue resulted in soil organic matter losses. Those results emphasize that higher corn yields may hold the potential for increased soil organic matter.

Higher Yield Effects Studied

Is it possible under today's higher yields and better management to think of corn as a potential soil improver? If corn yields are high enough, soil organic matter should increase.

This idea was tested using a long-term corn management experiment on the Macdonald Campus of McGill University near Montreal. The experiment, which began in 1984, involved the use of two fertilizer rates (normal and high), two population densities (normal and high), rainfed and irrigated systems, and two hybrids. The purpose was to determine the interaction among these inputs on soil organic matter levels. Populations were 26,000 and 36,000 plants per acre (65,000 and 90,000 plants per hectare). Fertilizer rates were 150-90-150 and 360-270-360 lb N, P_2O_5,

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and K_2O/A (170-100-170 and 400-300-400 kg/ha). Fertilization practices included preplant N, phosphorus (P), and potassium (K), starter N and P, and side-dressed N at the high N rates. For 5 years, liquid cattle manure was applied to supply 1.8 tons/A (4,000 kg/ha) of dry matter and 62 lb N/A (70 kg N/ha). Irrigation water was supplied the first 3 years using a drip system. Two hybrids were included for comparative purposes. If one of the cultivars yielded significantly lower it was dropped and replaced the next year.

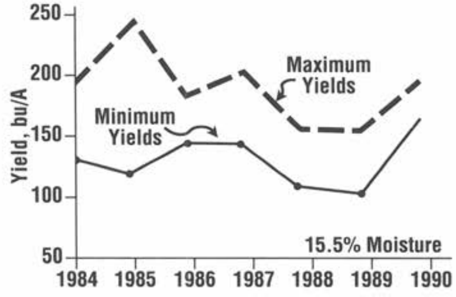


Figure 1. Corn yields over the life of the study.

Results

Hybrid and population density effects on yield and dry matter return to the soil were small, and there was no influence of these factors on soil organic matter. Irrigation increased corn yields two years out of three but there were no effects of irrigation on soil organic matter. For those reasons, only the fertilizer effects on soil organic matter will be discussed.

Maximum grain yields varied from 150 bu/A (9.4 tonnes/ha) to 242 bu/A (15.2 tonnes/ha); depending on the year (**Figure 1**). Low yields varied from 97 bu/A (6.1 tonnes/ha) to 169 bu/A (10.6 tonnes/ha). Stover inputs over the same period calculated in tons of carbon per acre varied from 1.25 to 2.10 tons/A (2.8 to 4.7 tonnes/ha), depending on the year and fertilizer rate (**Table 1**). Carbon from the added manure amounted to approximately 0.7 tons/A (1.6 tonnes/ha) per year.

Organic Carbon

Soil organic carbon levels (**Table 1**) were influenced by fertilizer rates and by time. Over the 6 years of production, the high rate of fertilizer increased the carbon return over the normal rate of fertilization by about 0.9 tons/A (2 tonnes/ha). The net result was that soil organic C increased from 18 tons/A (40.7 tonnes/ha) in 1984, to 19.4 tons/A (43.4 tonnes/ha) in 1987, to 21.4 tons/A (48.0 tonnes/ha) in 1990. During the same period, corn stover supplied 9 to 9.9 tons/A (20.3 to 22.2 tonnes/ha) of organic C, depending on fertilizer rate. Liquid manure provided 4.3 tons/A (9.6 tonnes/ha). The efficiency of conversion of organic C residue and manure C into soil organic C was about 23 percent.

Organic Nitrogen

Changes in average soil organic N contents during the experiment were not significant, but organic N was influenced by

Table 1. Carbon additions from corn stover and manure–1985 to 1989.

	Added in Stover		Added in Manure	Soil Organic Matter
	Low fertilizer rate	High fertilizer rate		
Year	Tons C/A	Tons C/A	Tons C/A	Tons C/A
1984	1.56	1.56	0.71	18.16
1985	1.92	2.10	0.71	
1986	1.61	1.70	0.71	
1987	1.43	1.52	0.76	19.38
1988	1.25	1.43	0.71	
1989	1.29	1.61	0.67	
1990				21.43
Additions	9.06	9.91	4.27	
Increase				3.26

Table 2. Effects of N from stover and manure on soil organic N levels.

	Nitrogen added in stover		Nitrogen	Soil organic nitrogen	
	Low fertilizer rate	High fertilizer rate	added in manure all plots	Low fertilizer rate	High fertilizer rate
Year	lb/A	lb/A	lb/A	lb/A	lb/A
1984	67	77	62	4,211	4,211
1985	55	76	62		
1986	71	81	62		
1987	54	64	66	3,638	3,877
1988	55	70	62		
1989	53	70	59		
1990				3,757	3,972
Additions	355	438	375		
Soil increase due to increased fertilizer rates					215

fertilizer rates after 3 and 6 years of production (**Table 2**). During the 6 years of the project, soil organic N in the high fertilizer treatment area gradually increased compared to the lower rate. Over the life of the study, N returned in the stover was 438 lb/A (490 kg/ha) for the high fertilizer rate vs. 355 lb/A (398 kg/ha) for the lower rate.

The high fertilizer rate resulted in about 214 lb/A (240 kg/ha) more soil organic N than the lower rate. The increase in soil organic N was greater than the differences in stover N between low and high fertilizer rates, suggesting some possible stimulation in organic N retention by the high fertilizer rate. Increases in organic N with increases in fertilizer rate were not large, but were important on a long term basis.

There is some question as to the quality of the organic matter that results from the corn production. Generally, C/N ratios increased over the 6-year period (8.6 to 11.1), but values were still within an acceptable range (**Table 3**). This increase does indicate that added soil organic matter was somewhat less humified than the original organic matter.

Summary

The results of this 6-year study indicate that residue returns from continuous corn production exceeded C decomposition in these soils, and that fertilizer rates can affect organic C and organic N levels in the soil. High levels of corn production can result in increased soil organic matter and improved soil quality.

Is corn a soil building crop? Certainly, but it requires optimum management and good returns of C and N to the soil. This can best be managed through a program that maximizes corn yields and nutrient returns to the soil. ■

Table 3. Changes in soil organic matter, organic N and C/N ratio after 3 and 6 years of production.

	Organic C		Organic N		C/N ratio	
			Fertilization Rate			
Year	Low	High	Low	High	Low	High
			% in soil			
1984	1.52		0.176		8.6	
1987	1.62		0.152	0.162	9.4	10.0
1990	1.74	1.83	0.157	0.166	11.1	11.0

Oklahoma

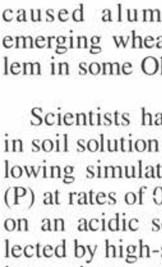
Aluminum Speciation and Soil Solution Composition in a Phosphorus Fertilizer Band

CULTIVATED SOILS tend to become acidic in the surface horizon with time, due to a combination of factors including loss of organic matter and addition of acid-forming fertilizers. This has caused aluminum (Al) toxicity in emerging wheat to be a significant problem in some Oklahoma soils.

Scientists have been studying changes in soil solution composition with time following simulated banding of phosphorus (P) at rates of 0, 30, 60, and 120 lb P_2O_5/A on an acidic soil. Soil solution was collected by high-speed centrifugation at various times after the application of fertilizer P and analyzed for Al, sulphate (SO_4), manganese (Mn), iron (Fe), calcium (Ca), and magnesium (Mg) as well as pH and ionic strength. Increasing levels of fertilizer P resulted in increased soil solution pH, ionic strength, SO_4 and phosphate (PO_4) concentrations and decreased concentrations of Al, Ca, Mn, Mg, and potassium (K).

The differences were still significant 70 days after fertilizer application. The sharp decrease in Al^{3+} in soil solution following fertilizer P application was due primarily to complexation with HPO_4 and H_2PO_4 ions. In this experiment, the greatest decrease in Al^{3+} concentration was obtained with 60 lb/A of banded P_2O_5. Further additions of P fertilizer did not substantially increase the amount of Al^{3+} complexed. ■

Source: J. J. Sloan and R. L. Westerman, Department of Agronomy, Oklahoma State University. Abstract for Departmental Seminar, February, 1992.



Saskatchewan

Strip Trials Improve Fertilizer Recommendations

SINCE 1990, the Saskatchewan Soil Testing Laboratory has been using strip trials to address fertility concerns raised by producers. With the help of local fertilizer dealers and assistance from lab technicians, test strips are placed in the cooperator's field to evaluate various fertility practices. The cooperator performs all field operations, including application of the fertilizer treatments.

Results from some of the 12 trials established in 1991 are shown in the table. Field trials like these increase farmers' confidence in fertilizer practices and provide a basis for the laboratory to improve fertilizer recommendations. ■

Location	Crop	Treatment	Yield response, % of control
Leoville	canola	$CuSO_4$	104
Prince Albert	wheat	$CuSO_4$	125
Laporte	wheat	KCl	112
Cudworth	barley	KCl	119
Wynyard	canola	K_2SO_4	109
Shellbrook	canola	Elemental S	124
Brooksby	canola	Boron	119

Source: G. Kruger. January/February 1992. *The Analyzer,* Saskatchewan Soil Testing Laboratory, University of Saskatchewan, Saskatoon.

Progress Without Profit

The temperature outside was 101 degrees. I watched the Wimbledon tennis matches, live, in the comfort of an air-conditioned room. Without moving, I pressed a button and watched the golf matches in California. I saw both better than if I had been there. Miraculous!

A friend was in the hospital recently–chest pains. The emergency crew reacted immediately. Complex tests, impressive equipment–the next day a triple by-pass–the ultimate in scientific achievement. Complete recovery. Thirty years ago he would have died. Brilliant!

The farmers I visited had the latest expensive farm machinery, used the appropriate chemicals, planted varieties developed through years of plant breeding and genetic engineering. Maybe not as glamorous as the changes in electronics and medicine, but quite impressive. Wonderful!

But despite the technological discoveries in agriculture, little progress has occurred in two areas: (1) Too many people in the world are not fed properly or adequately. The whole system of production and distribution, including the U.S. farm program, is not working as it should. (2) The average farmer fails to make a reasonable profit–return on his investment and labor. Progress without profit.

Great minds produce great technological achievements in electronics, medicine, and agriculture! When are we going to assign such great minds to the task of developing a farm system that both feeds and flourishes? Are these discoveries simplifying or complicating the issue?

J. Fielding Reed

Better Crops
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