BETTER CROPS

with plant food

SUMMER 1984

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BETTER CROPS with plant food

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Contents

Our cover: Fertilizing and managing soils for high yields can have many positive effects in reducing erosion. Earlier canopy closure, increased water infiltration, greater root growth, and more crop residues offer excellent protection against soil loss. Photos, clockwise from top left: chisel tillage leaves crop residue and a rough surface to reduce erosion; erosion in a corn field with conventional tillage (photo by Bruce Julian, Conservation Tillage Information Center); sheet erosion in a soybean field (photo by Tim McCabe, USDA Soil Conservation Service); a vigorous, well-fertilized soybean field.

Dr. N.D. Morgan Honored with 1984 "Distinguished Grasslander Award"

DR. NIVEN D. MORGAN, a prominent Louisiana scientist and forage farmer, was recently recognized for his work in forages by the American Forage and Grassland Council. He was one of 4 individuals in the United States and Canada to receive a 1984 Distinguished Grasslander Award at the Council's conference in Houston.

Dr. Niven Morgan

The award is presented to individuals who, during their careers in the forage and grassland segment of agriculture, have served with distinction.

Dr. Morgan's career included more than 30 years as an agronomist with the Potash & Phosphate Institute (PPI). During that time, he encouraged the production and utilization of high quality forages in Texas, Oklahoma, Louisiana, and Arkansas. By actively supporting research and demonstrations on improved forage practices, he became recognized as one of the South's most influential forage professionals.

While his early work involved tissue testing and fertility needs of cotton, Dr. Morgan saw the opportunities for improved pasture and beef cattle production in the South. His perception of proper management of bermudagrass for intensive beef production included ample fertility plus maintaining the grass in a vegetative state, by grazing or mowing. He also was instrumental in developing management systems for overseeding of ryegrass for cool season forage.

Dr. Morgan's work has also been recognized by previous awards, including: Certificate of Appreciation from Louisiana State University in 1983; Louisiana Forage Council Award in 1980; Outstanding Service to Arkansas Agriculture Award in 1972; and the American Forage and Grassland Council Merit Certificate Award in 1970.

Since retiring from the Potash & Phosphate Institute in 1972, Dr. Morgan has operated his 1900-acre forage-beef cattle farm near Minden, Louisiana. He continues to be a strong supporter of PPI programs and is active in all areas of forage production. He and his wife Jeanette live in Shreveport. They have 3 sons and 7 grandchildren. ■

"A TRUSTED FRIEND . . . an intensely loyal supporter of PPI . . . and a highly respected expert and practitioner in the field of grassland farming. You can say it many ways, probably better, but that's how I feel about Niven Morgan. Even after more than 40 years advising, promoting, and practicing good forage management, he continues in hot pursuit of the kinds of truths that will help grasslanders. He will never be forgotten . . . nor will he forget us. Thank you, Niven."

– Dr. R.E. Wagner, President
Potash & Phosphate Institute
Foundation for Agronomic Research

How Many Soil Samples Do I Really Need?

By Emmett E. Schulte

THE NEED for proper soil sampling is becoming more critical than ever. One reason is the increasing emphasis on localized placement of fertilizer, such as banding, row, dribble or other methods. Also, the results of soil tests are normally used for planning lime and fertilizer programs 3 or 4 years ahead.

The Soils Department of the University of Wisconsin-Madison recommends taking a minimum of one composite sample per 5 acres for lime and fertilizer recommendations. More cores would be desirable, but in that case they should be pre-mixed in a clean container and one pint of the mixed soil should be sent to the soil testing lab.

A grower might pose the question: "Are that many samples really necessary if I have a uniform field, or is the Soils Department just trying to drum up business for the Soil Testing Labs?"

Consider the 20-acre field shown in **Figure 1**. This field was divided into 5-acre quarters for sampling purposes. Sample 1 was taken from the 5-acre quarter downslope from the barnyard. Consequently, it was extremely high in phosphorus (P) and potassium (K). The other 3 quarters are low. If the entire 20-acre field were sampled as a single unit, the P test would be 94 lb/A or "very high" and no corrective P_2O_5 would be recommended. Maintenance phosphate would be half of the rate for soils testing "high" or lower. Similarly, the K test would be 331 lb/A, and no corrective potash would be recommended. Yet, three-fourths of the field is low in P and K. Production would be reduced without corrective P_2O_5 and K_2O.

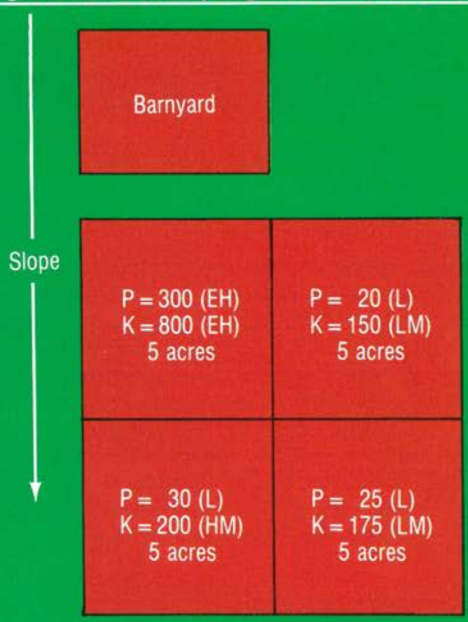
If the field were sampled in 5-acre units as recommended, the high results from the quarter close to the barn would be rejected by the computer in making fertilizer recommendations. The average P test from the remaining three quarters would be 25 lb/A, and a corrective recommendation of 60 lb/A of P_2O_5 would be made. The average K test would be 175 lb/A, resulting in a corrective K recommendation of 160 lb of K_2O/A for each of 2 years.

In this example, sampling the 20-acre field as a single field rather than in 5-acre units saves $7.50 in soil testing fees. But a conservative estimate of yield reduction due to lack of corrective fertilizer would be 15 bu/A of corn and 0.5 ton/A of alfalfa per year.

Saving on soil sampling can be penny-wise and pound-foolish. ■

Dr. Schulte is Extension Soil Scientist, University of Wisconsin-Madison.

Figure 1. Soil Sampling in a 20-Acre Field.



	Avg. of 20 acres	Avg. of 3 quarters
Soil P	94 (VH)	25 (L)
Soil K	331 (H)	175 (LM)
Corr. P_2O_5	0	60 lb/A
Corr. K_2O	0	160 x 2*

*The 2 indicates the rate should be applied twice or two successive years.

H = High
L = Low
LM = Low-medum
HM = High-medium
VH = Very high
EH = Extremely high

New Book Examines Soil Nutrient Bioavailability

AFTER 30 YEARS of research on the availability of nutrients to plants, Dr. Stanley A. Barber has authored a book: *Soil Nutrient Bioavailability*. This explains Dr. Barber's mechanistic approach to describing plant uptake of soil nutrients and shows why his basic approach reduces the necessity of conducting numerous crop-fertilization experiments to gain information about each crop-soil combination.

Dr. Barber is Professor of Agronomy at Purdue University, West Lafayette, IN. The book presents a separate chapter on each of twelve nutrients, and incorporates his basic findings from laboratory research and fertility experiments in field plots.

Soil Nutrient Bioavailability serves as a reference for university and industry scientists in soils, crops, plant physiology, botany, biology, and horticulture. It also serves as a textbook for undergraduate and graduate students in soil fertility and plant nutrition.

The new book is a Wiley-Interscience Publication of John Wiley & Sons. ■

High Yields — A Deterrent to Soil Erosion

By Jerry V. Mannering

MOST CONSERVATIONISTS talk about conservation tillage, sod-based crop rotations, contouring, terracing, etc. as effective means of erosion control. And they certainly can be effective. However, we often fail to give credit to some of our accepted cultural practices and their effectiveness in reducing soil erosion. For example, high plant population, narrow rows or solid seeding, and last, but not least, **proper fertilization that results in high crop yields.**

How High Yields Help Control Erosion

Well fertilized soils that result in high crop yields have both direct and indirect effects on soil erodibility.

Direct effects include the following: (1) a more rapid crop canopy closure which reduces the erosive energy of raindrops; (2) higher yields of growing plants both above and below ground which reduces soil detachment, increases infiltration, thus reducing runoff and anchors more of the soil because of the more vigorous roots; and (3) the production of more crop residues which when left on the soil surface is tremendously effective in controlling erosion.

Indirect effects are residual. The more dry matter produced, the more root growth and the more total plant material turned under or left on the surface, the greater the soil organic matter content. Soil organic matter improves soil tilth through increased soil aggregation. This in turn leads to more water infiltration, thus less runoff as well as increased resistance of soils to detachment. Both factors result in less soil erosion.

Research Results

Researchers have known for some time that there is an inverse relationship between crop yields and runoff and soil loss. Reporting on an extensive analyses of 8,000 plot-years of soil loss data from 21 states, W.H. Wischmeier concluded that "crop yields appeared to provide a convenient and adequate measurement of the combined effects of several significant variables, such as quantity of root growth, density of canopy, rate of water use by crops, soil fertility and quality of crop residue."

There is limited research data that directly compares crop yields to soil loss. Some of this is presented in **Table 1.**

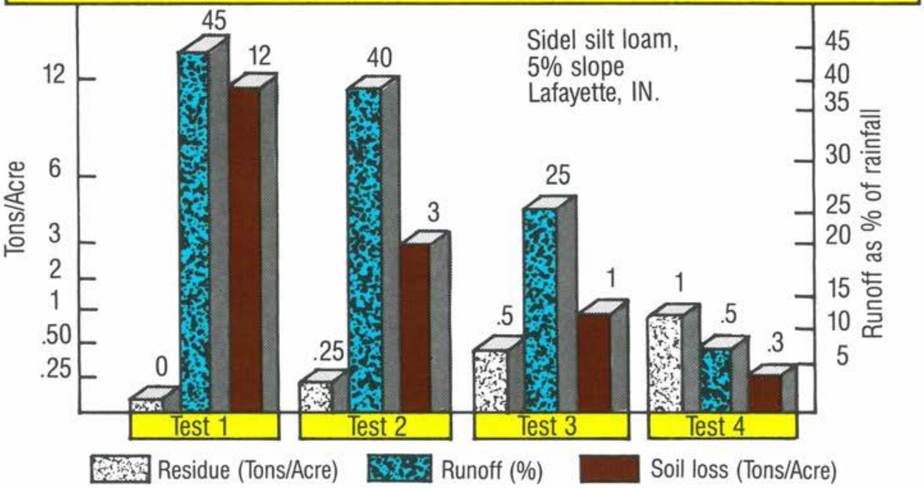
Table 1. Effect of Fertilizer Rates on Corn yield, Runoff, Soil Loss and Soil Organic Matter. Marshall silty clay loam - 9% slope Clarinda, Iowa - (10-year avg.)

Fertilizer (lb/A)			Corn yield (bu/A)	Runoff (in.)	Soil Loss (T/A)	% Organic Matter - '63
N	P_2O_5	K_2O				
0	23	0	73	1.9	10.3	2.8
179	23	0	107	1.4	6.7	3.0

Moldenhauer, W.C. et al. 1967. The Influence of Crop Management on Runoff, Erosion, and Soil Properties of a Marshall Silty Clay Loam. Soil Sci. Soc. Amer. Proc. 31:541-546.

Dr. Mannering is Extension Agronomist, Purdue University, West Lafayette, IN.

Figure 1. Effect of Surface Residue on Runoff and Soil Loss.



Source: Mannering, J.V., Using Crop Residues for Winter Protection, Crops and Soils Notes No. 424, Agronomy Dept., Purdue University.

In addition to the inverse relationship between fertilizer-crop yield and runoff-soil loss, these data also demonstrate the effects of increased yield on soil tilth through increased soil organic matter.

An example of how increased surface residues decrease soil erosion is given in **Figure 1.**

Surface cover of course can be controlled by the tillage system used but certainly crop yields determine to a great extent the amount of residue that "conservation-type" tillage systems have to work with. The information presented in **Figure 1** strongly supports the concept of surface residues as a means of controlling erosion.

Crop yields, especially corn, in recent years have increased appreciably and would be expected to have a much greater influence in controlling erosion. A rule of thumb is that for each bushel of corn produced you get 55 lb of residue; for each bushel of soybeans, 80 lb; and for each bushel of wheat, 100 lb. So you can see that we have greatly increased potential for controlling erosion just from the amount of residue produced.

Even if this amount of residue is turned under, soil erosion control benefits will occur. The effect will be even more dramatic if much of the residue is left on the soil surface using some form of conservation tillage.

The cropping-management factors (C-values) used currently by the Soil Conservation Service in Indiana and other states illustrate just how much control can occur from conservation tillage systems that leave large amounts of residue on the surface.

With 1,000 to 2,000 lb/A crop residues on the surface after planting, a chisel system lost 89% as much soil as the fall plow system. With more than 6,000 lb/A residues, the soil loss was only 20% as much.

Summary

In general, we can say that increased crop yields brought about by proper fertilization have positive effects both direct and residual in reducing soil erosion. In certain situations, such as highly erosive fragile lands, increasing fertility may not result in increased yields because of other major limitations such as water holding capacity. In the more extreme cases other solutions may be necessary. **Certainly, high crop yields that result from good management are very important as part of the overall solution to excessive soil erosion.** ■

Potash for Irrigated Alfalfa Boosts Yield and Reduces Stand Loss

By Craig C. Sheaffer

WHEN USING IRRIGATION to increase alfalfa yield, levels of other factors affecting production must be increased. A recent study at the Irrigation Research and Demonstration Center, Staples, Minnesota, showed that potash (K_2O) fertilization had a greater effect on irrigated alfalfa yields than either variety selection or harvest management. In that study on a sandy loam soil, pH was maintained at 6.6 while phosphorus (P) level was 50 lb/A. Boron (B) and sulfur (S) were applied according to Minnesota soil test recommendations.

Forage Yield

For both irrigated and unirrigated alfalfa, increases in annual K_2O application rates increased alfalfa dry matter yield (**Table 1**). However yield response to K_2O was greater when moisture was not limiting. Yield of unirrigated alfalfa fertilized with 540 lb K_2O/A was similar to that of unfertilized, irrigated alfalfa. This illustrates the positive effects of K_2O fertilization in reducing moisture stress. It also shows that even though moisture may not be limiting for plant growth, insufficient soil fertility will limit production and moisture use efficiency. **Yield of alfalfa which was irrigated and fertilized with 540 lb K_2O/A was 6.1 tons/A, or 2 tons/A greater than for unirrigated alfalfa fertilized with the same rate.**

Profits Boosted

For both irrigated and unirrigated alfalfa, K_2O fertilization increased profit. For example, based on a K_2O cost of 12¢/lb and a hay value of $84/ton ($75/ton at 12% moisture), the profit from applying 540 lb K_2O/A to irrigated alfalfa was $103 and $57/A greater than for the 0 and 180 lb K_2O/A rates. With

Table 1. Dry matter yield and nutrient uptake of unirrigated and irrigated alfalfa receiving variable annual K_2O rates.*

	Annual K_2O rate	Soil test K	Alfalfa Yield	N	K	P	Ca	Mg	Zn	B	Cu	Mn
	-----lb/A	-----	tons/A	---------	---------	---------	---------	-lb/A-	---------	---------	---------	---------
Unirrigated	0	94	2.9	186	73	12	118	24	0.14	0.36	0.07	0.48
	180	154	2.9	190	75	13	116	24	0.13	0.34	0.07	0.46
	360	521	3.0	186	122	13	104	19	0.16	0.36	0.08	0.43
	540	575	4.0	248	194	17	127	22	0.17	0.43	0.08	0.58
Irrigated**	0	66	4.1	262	140	22	152	30	0.16	0.40	0.09	0.51
	180	99	5.0	330	182	23	212	46	0.22	0.49	0.09	0.59
	360	264	5.2	333	246	24	167	34	0.21	0.51	0.10	0.56
	540	524	6.1	354	356	27	186	31	0.22	0.59	0.12	0.65

*A 2-year old stand of '520' alfalfa was harvested 3X at first flower.
**Ten inches applied based on recommended Minnesota irrigation scheduling procedures (MN Extension MP-160, 1978).

Dr. Sheaffer is with the Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul.

Table 2. Residual effect of K_2O application on following season (first cutting) dry matter yields of unirrigated and irrigated alfalfa.*

	Previous annual K_2O applications — lb/A			
	0	180	360	540
	---------tons/A ---------			
Unirrigated	2.9	3.0	3.1	3.3
Irrigated	2.2	2.4	3.5	3.5

*Residual — first harvest at first flower, treatments applied previous year.

the large financial inputs associated with irrigation, it is very apparent that high levels of fertilization are justified to increase returns.

Alfalfa Persistence

Although irrigation can increase alfalfa yield, it can also increase the incidence of disease and winter injury **(Table 2).** Residual yields were measured in the spring following a severe winter. Alfalfa which received zero and 180 lb K_2O/A had lower yields and worse stand than when not irrigated. High levels of K_2O fertilization reduced winter injury and stand loss, and boosted residual first cutting yields.

Nutrient Uptake

With greater yields associated with irrigation and potash fertilization, uptake of essential plant nutrients is also increased **(Tables 1 and 3).** Since continued uptake may ultimately lead to nutrient deficiencies, a complete soil fertility program based on local soil test recommendations must be implemented. Boron and sulfur are especially important for alfalfa production on sandy soils. Average levels of B and S in alfalfa herbage were greater than 40 ppm and 0.3%, respectively. Concentrations of both nutrients decreased slightly with increases in K_2O fertilization but were always sufficient.

It is interesting that for the highest yield the N and K taken up by the crop were nearly equal. Increased alfalfa yields associated with irrigation resulted in lower levels of soil K than for unirrigated alfalfa **(Table 1).** But, irrigation may also move potassium and other mobile nutrients down in the profile in sandy soils.

Forage Quality

Irrigation decreased forage digestibility but did not affect crude protein concentration (average of 19%). Average forage digestibility *(in vitro)* was 63.1 and 60.1% for unirrigated and irrigated alfalfa, respectively. The greater digestibility for unirrigated alfalfa can be attributed to greater leafiness and lower levels of structural chemical entities. Potash fertilization did not affect digestibility or protein concentration in the forage. ■

Table 3. Dry matter yield and nutrient uptake per ton of yield for unirrigated and irrigated alfalfa fertilized with 540 lb/A K_2O.

	Yield	N	K*	P*	Ca	Mg	Zn	B	Cu	Mn
	tons/A	----------------------------lb/ton----------------------------								
Unirrigated	4.0	62	49	4.3	32	5.5	0.04	0.11	0.02	0.14
Irrigated	6.1	58	58	4.4	31	5.1	0.04	0.10	0.02	0.11

*K X 1.2 = K_2O; P X 2.3 = P_2O_5

Fertilizing Tall Fescue and White Clover on Low Fertility Soils

By C.H. Burmester and Fred Adams

THE PRACTICE of planting row crops in the Southeast on a farm's more productive areas has generally relegated pastures to the less productive soils. Low cattle prices have helped to keep them there. In spite of this, the soil fertility requirements of pastures in the region are woefully neglected. Much of this land is planted to tall fescue, probably because it persists well on these soils even with their low management levels and their low fertility levels. Sometimes, white clover is interplanted with tall fescue to improve forage quality and also to provide a nitrogen (N) source for the pasture.

Two experiments were initiated in 1978 to study the effects of N, phosphorus (P_2O_5), and potassium (K_2O) fertilizer rates on the establishment and yield of tall fescue, with and without white clover in the sward, on soils in northern Alabama that were suffering from poor management and low fertility. The test sites were located in farmers' pastures. At each site, a half-acre area was completely renovated and fenced to prevent grazing. After turning and smoothing the soil, one-half of the area was seeded with 'Kentucky 31' tall fescue and the other half with a mixture of tall fescue and 'Regal' Ladino white clover.

One site was on a Wynnville sandy loam, a representative soil of the Appalachian Plateau, and the other was on a Dickson silt loam, a typical soil of the Highland Rim. Both soils represent extensive acreages of pastureland. According to the dilute, double-acid extraction method (Mehlich 1), both soils were "very low" in P; the Wynnville soil was also "low" in K, and the Dickson soil was medium in K **(Table 1)**.

Table 1. Initial soil test values

Soil test values	Wynnville fine sandy loam	Dickson silt loam
pH	6.1	6.5
P (lb/A)	4 (very low)	4 (very low)
K (lb/A)	50 (low)	84 (medium)
CEC (meq/100g)	6.1	7.8

Nitrogen rates were 0, 60, 120, and 180 lb/A; both P_2O_5 and K_2O rates were 0, 30, 60, and 120 lb/A. One-half of the N and all of the P and K fertilizers were applied annually in September; the remainder of N was applied in March. Plots were arranged in a randomized complete block design with four replications.

Forage was harvested with a flail mower when growth was 6-8 inches tall. Three harvests were made each year on the Wynnville soil, and four were made on the more productive Dickson soil. Each test was conducted for three years.

Forage yields were considerably higher on the Dickson soil than on the Wynnville soil. This is believed to have been caused by a near-level topography and a wintertime perched water table above an impervious fragipan in the Wynnville soil. This led to poor drainage during the winter (too much soil water) and excessive drought stress during the summer.

Effect of N Fertilizer

Each increase in N-fertilizer rate increased the forage yield of tall fescue on both soils **(Table 2)**. Forage yield of the fescue-clover also increased with increasing N rate, but the increase was at the expense of the white clover stand **(Table 2)**.

Mr. Burmester and Dr. Adams are with the Agronomy and Soils Department, Auburn University, Alabama.

Table 2. Effects of Nitrogen Fertilizer Rates on Annual Forage Production by Tall Fescue and Tall Fescue-White Clover Mixture.						
	Wynnville fsl			Dickson sil		
Annual N rate	Fescue dry forage	Fescue-clover dry forage	Clover[1] in sward	Fescue dry forage	Fescue-clover dry forage	Clover[1] in sward
lb/A	lb/A	lb/A	%	lb/A	lb/A	%
0	420	2,700	54	4,180	6,570	30
60	2,100	2,920	30	5,970	7,250	17
120	3,110	3,640	9	7,040	8,160	1
180	4,430	—	—	7,480	—	—

[1]At conclusion of experiment.

The highest rate of N (120 lb/A) almost eliminated clover from the sward. On the Wynnville soil, N fertilizer caused clover to be replaced by weeds; on the Dickson soil, clover was replaced by tall fescue.

The optimum N rate for fescue was 180 lb/A on the Wynnville soil and 120 lb/A on the Dickson soil. For the fescue-clover mixture, it was probably zero because of the detrimental effect of N fertilizer on clover stands. However, yield of the fescue-clover mixture was quite low in early spring before clover started fixing N. Thus, a low rate of N in late winter might stimulate fescue growth enough to provide additional early spring forage without seriously depleting the clover stand. This forage would have to be grazed, however, to prevent too much competition with the white clover.

Effect of P Fertilizer

Phosphorus fertilizer greatly increased forage production of both tall fescue and white clover. The first increment of P fertilizer (30 lb/A of P_2O_5) increased fescue yields nearly five-fold on the Wynnville soil but only about 20% on the Dickson soil **(Table 3)**. On both soils, the highest fescue yields were obtained with a P_2O_5 rate of 60 lb/A. Fescue-clover forage showed a dramatic four-fold increase with the lowest rate of P fertilizer (30 lb/A of P_2O_5) on the Wynnville soil, and yields were still increasing with the highest rate of P_2O_5 (120 lb/A). On the Dickson soil, maximum fescue-clover forage was produced with 60 lb/A of P_2O_5 **(Table 3)**. Although both soils were equally low in soil-test P, fertilizer P was utilized more efficiently on the higher yielding Dickson soil.

Without P fertilizer, white clover was unable to persist on either soil **(Table 3)**. Since a 2:1 ratio of tall fescue to clover is often considered optimum, these data show that an annual P_2O_5 rate of at least 30 lb/A is needed to maintain clover in the sward **(Table 3)**.

Table 3. Effects of Phosphorus Fertilizer Rates on Annual Forage Production by Tall Fescue and Tall Fescue-White Clover Mixture.						
	Wynnville fsl			Dickson sil		
Annual P_2O_5 rate	Fescue dry forage	Fescue-clover dry forage	Clover[1] in sward	Fescue dry forage	Fescue-clover dry forage	Clover[1] in sward
lb/A	lb/A	lb/A	%	lb/A	lb/A	%
0	500	300	2	5,350	3,710	3
30	2,470	1,260	36	6,530	5,010	30
60	3,380	1,810	58	7,010	6,230	34
120	3,110	2,700	54	7,040	6,570	30

[1]At conclusion of experiment.

(continued on next page)

Table 4. Effects of Potassium Fertilizer Rates on Annual Forage Production by Tall Fescue and Tall Fescue-White Clover Mixture.						
	Wynnville fsl			Dickson sil		
Annual K_2O rate	Fescue dry forage	Fescue-clover dry forage	Clover[1] in sward	Fescue dry forage	Fescue-clover dry forage	Clover[1] in sward
lb/A	lb/A	lb/A	%	lb/A	lb/A	%
0	1,960	740	28	6,400	5,610	23
30	2,920	1,410	27	7,010	6,520	33
60	2,910	2,220	54	7,080	6,330	39
120	3,110	2,700	54	7,040	6,570	30

[1]At conclusion of experiment.

Effect of K Fertilizer

The optimum tall fescue yield on both soils was produced by annual applications of 30 lb/A of K_2O **(Table 4)**. The optimum K_2O rate for the fescue-clover was 120 lb/A on the Wynnville but only 30 lb/A on the Dickson soil **(Table 4)**. Fescue-clover yields were nearly doubled with the first increment of K fertilizer on the Wynnville soil but increased only 15-20% on the Dickson soil **(Table 4)**.

Potassium fertilizer was needed on both soils to maintain the proper amount of clover in the pasture. These data show that 30 lb/A of K_2O annually was needed to maintain clover in the sward on the Dickson soil, and 30 to 60 lb/A on the Wynnville soil **(Table 4)**.

Conclusion

Proper fertilization of low fertility soils can greatly increase forage production of tall fescue or a mixture of tall fescue and white clover. White clover was maintained in the tall fescue sward by using a low rate of N and adequate rates of both P and K. Forage production of tall fescue alone requires more N but less P and K fertilizers than does a sward mixture of fescue and clover. In general, the pasture should be fertilized to meet the fertility requirements of the clover if a desirable species mix is to be maintained. ■

Balanced Fertility Increases Profitability of Broccoli

By James W. Paterson

BROCCOLI is an intensively managed, high-value crop. A mistake made in any phase of production management can be very costly.

Data from recent work at the South Jersey Research Center show the impact which a balanced fertilizer program can have. A fall broccoli study was established on a sandy loam soil. Long-term soil fertility plots tested very high in phosphorus (P), medium in boron (B), and low to medium in potassium (K), depending on the previous year's treatments.

Dr. Paterson is with the Rutgers Research & Development Center, Bridgeton, New Jersey.

The entire plot area was limed to a pH of 6.5. Apollo variety broccoli was seeded on July 15 in 3 ft. rows with a final plant stand of one foot apart within the row. A once-over harvest was made on September 28.

Table 1 shows the large difference in yield, quality, and gross return per acre of broccoli with balanced fertilization. Nitrogen (N) at 100 lb/A without potash or boron had the lowest yield and the smallest head. When N application was increased to 300 lb/A, the yield of broccoli increased from 398 to 506 crates per acre. When K was added, both head size and the yield of good-excellent quality broccoli increased substantially. Potash treatments improved plant growth and development, increased plant height and encouraged better broccoli holding ability in the field.

Highest yields and the greatest gross return per acre, however, were achieved when all four nutrients (N, P, K and B) were applied in a well balanced soil fertility program.

Note how head size, crates per acre, and gross returns all increased when a balanced nutrient program was used. Gross returns were almost $1,800 per acre higher from the poorest to the best soil fertility management practices.

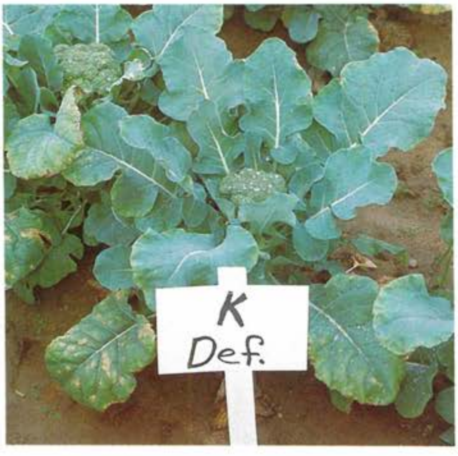
That's a hefty return for using sound fertilizer management decisions. ■

Table 1. Broccoli Response to Balanced Fertility: Yield, Quality, Returns.

Fertilizer* Treatments (lb/A)			Good-Excellent Quality		Gross** Returns
N	K_2O	B	lb/Head	Crates/A	$/A
100	0	0	0.69	398	2,846
300	0	0	0.70	506	3,618
300	150	0	0.87	602	4,304
300	150	2	0.92	648	4,633

* All treatments also received 100 lb/A P_2O_5.
** Based on an average seasonal price of $7.15/crate.

A HEALTHY, "ideal" broccoli plant.



POTASSIUM (K) deficient broccoli plant.

How a Champion Corn Grower Fertilizes and Manages for 300 bu/A

By Roger Vinande

ERNEST DIXON has won the National Corn Growers Association (NCGA) yield contest the last 4 years. During the last 3 years he has had corn yields over 300 bu/A (16,800 lb of grain). See **Figure 1.** Ernest and his brother Leslie ("Scoop") raise 500 acres of corn near Thornton in San Joaquin County, California. Their overall farm average during this period of years has been near or above 250 bu/A.

Dixon attributes his bin-busting yields to a combination of soil fertility management, soil physical condition, and corn hybrid selection. His record corn yields have all been with Pioneer® hybrid 3183.

Nitrogen

To achieve these 300 bu/A yields, Dixon injects 400 lb/A of nitrogen (N) as 20% aqua-ammonia solution at a depth of 9-10 inches in the spring before planting. Then at planting he applies 35 gallons of 4-10-10 solution with 0.5% zinc 3 inches to the side and 3 inches below the seed. After the corn is up, he sidedresses 400 lb/A of 6-20-20 dry fertilizer 10 inches deep on both sides of the corn row. See **Table 1.**

P and K

Dixon has his soil tested every year to fine tune his fertility program. He adds phosphorus (P) and potassium (K) because he feels he gets a yield response even though the annual soil tests indicate a high level of phosphorus and medium to high levels of potassium. When the potassium soil test drops below the medium level, he adds 400 lb/A of muriate of potash.

Table 1. Nutrients Added to Dixon Corn in 1983.

N	P_2O_5	K_2O	S	Zn
		lb/A		
438	115	115	32	1.75

Sulfur and Micronutrients

The 6-20-20 sidedressed fertilizer supplies 32 lb/A of sulfur and in addition 250 lb/A of popcorn sulfur is broadcast every 3 years to assure a steady supply of "slow release" sulfur. Zinc is banded at the rate of 1.75 lb/A with the 4-10-10 starter solution.

To date the soil tests have shown sufficient amounts of the other micronutrients and none other than zinc have been applied.

The soil pH is maintained between 6.5-7.0 with fall applications of sugarbeet lime when needed.

Soil Management and Tillage

Dixon believes in maintaining a loose, well-aerated soil that will allow maximum water movement and root development. He prefers to V-chisel his corn stubble to a depth of 18 inches in the fall, but his 300 bu/A fields must be moldboard-plowed since the stalk residue is so thick he can't get the chisel through the field. In the spring one or 2 passes with a disk are made before injecting the aqua-ammonia.

Preplant herbicides are incorporated about 3 inches deep with a disk, flextine harrow, and Brillion roller hooked in combination. Another set of Brillion

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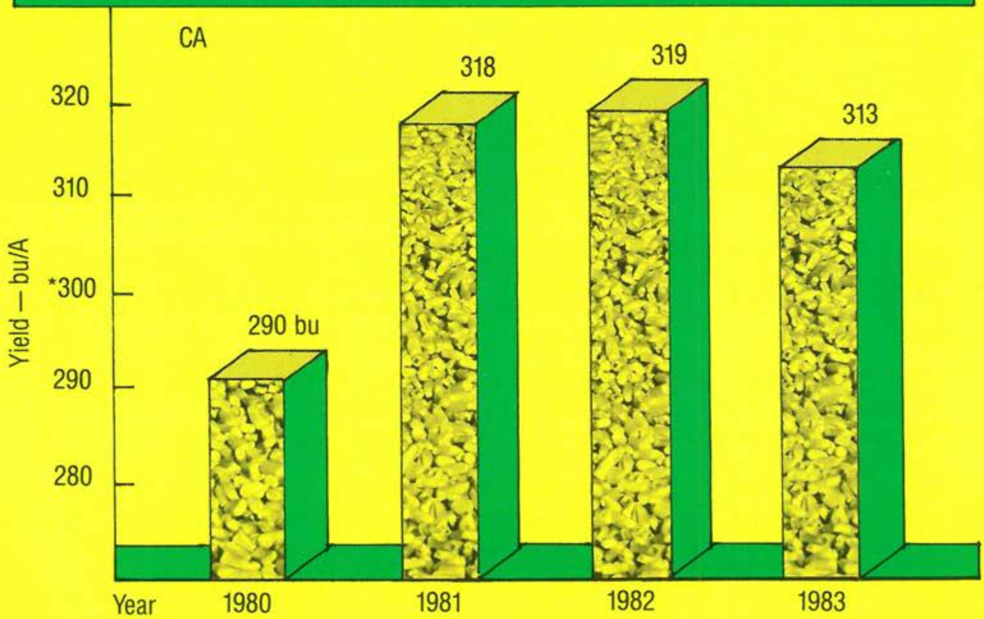
Figure 1. Dixon NCGA Winning Corn Yields.



**300 bu = 16,800 lb of grain, 15.5% moisture*

rollers is hooked behind a float made of four 3x12x20-foot wooden planks set at a 17-degree angle to firm the soil for planting.

Later Dixon runs a rolling cultivator down the corn rows once to form the irrigation furrows.

Corn after Corn

Dixon has had no problems raising corn after corn in the same fields as long as nutrients are replaced and the soil is kept in good physical condition. One of his fields has been in corn for 24 consecutive years and the yields are still increasing. He is careful about minimizing compaction by avoiding tilling the soil when it is too wet.

His corn is planted in 30 inch rows at a population of 34-36,000 plants per acre by April 10th if weather permits. The soil must be a minimum of 53°F at the 4 inch depth before planting is begun. In 1983 his high yield plot was planted on May 22nd because of prolonged spring rains. This late planting probably accounts for the slightly lower yield than in 1981 and 1982.

Irrigation

To raise 300 bu/A corn you must not stress it for nutrients or water. Dixon irrigates his corn 6-7 times applying a total of 30 inches of water. Depth to the water table is only 7 feet so the corn may be obtaining some of its needs from ground water.

Water is applied every 7-10 days during the critical pollination stage to keep the humidity in the crop canopy to a maximum. Irrigation is continued long enough in the growing season to keep the plants growing vigorously through kernel black layer formation.

Summary

Ernest Dixon has shown that 300 bu/A corn yields can be attained year after year by: (1) minimizing plant stress, (2) selecting a hybrid with high yield potential, (3) keeping nutrients at optimum soil test levels, and (4) maintaining good soil structure and aeration. ■

Seven Graduate Students Receive PPI Fellowship Awards

THE POTASH & PHOSPHATE INSTITUTE (PPI) presented seven graduate students in soil and plant science with the PPI Fellowship award. The awards of $2,000 each encourage academic excellence among candidates for either the M.S. or Ph.D. degree.

The 1984 winners were selected from a field of nearly 50 applicants and are:

- **Dan W. Gill,** North Carolina State University, Raleigh, NC;
- **Cynthia A. Grant,** University of Manitoba, Winnipeg, Man.;
- **William E. Jokela,** University of Minnesota, St. Paul, MN;
- **Michael C. Karr,** Purdue University, West Lafayette, IN;
- **Gary A. Kruger,** University of Saskatchewan, Saskatoon, Sask;
- **Jed Myers,** Ohio State University, Columbus, OH;
- **Richard J. Roseberg,** Oregon State University, Corvallis, OR.

"The 1984 class of applicants for PPI Fellowships truly represented an exceptionally well qualified group," declared Dr. R.E. Wagner, President of PPI and the Foundation for Agronomic Research (FAR). "Each year, we are impressed by the academic credentials and letters of recommendation which these young people present in their applications and we are proud to have a small part in encouraging such excellence." Scholastic record, excellence in original research, and leadership are some of the major qualifications evaluated.

Dan W. Gill received the M.S. degree in soil fertility at North Carolina State University in August 1983, and is now working toward the Ph.D. degree. His research program involves potassium uptake and soil dynamics in an upland cropping system in Central Sumatra, Indonesia. His long-term goals include involvement in agricultural programs in developing countries. Mr. Gill was born in Bolivia and received his B.S. degree from Colorado State University.

Cynthia A. Grant is pursuing the Ph.D. degree in soil science at the University of Manitoba, where she also earned B.S. and M.S. degrees. Mrs. Grant's Ph.D. thesis deals with potassium nutrition of barley on high magnesium soils. Her research could help develop methods of potassium fertilizer management for optimum yields on high magnesium soils. She is being sponsored by Agriculture Canada as a Research Branch Ph.D. trainee out of the Brandon Research Station. For her M.S. thesis, Mrs. Grant studied nitrogen and phosphorus fertilization in the production of winter wheat under zero-tillage management.

William E. Jokela hopes to pursue a career in applied research and extension or teaching in soil fertility after completion of his Ph.D. program at the University of Minnesota. His research work is on the effect of time and rate of nitrogen (N) application on corn yield and fertilizer N recovery. The program is aimed at attaining maximum corn yields by improving N fertilizer efficiency under non-irrigated conditions. Mr. Jokela is a graduate of Carleton College and received the M.S. degree at the University of Minnesota.

Michael C. Karr earned a B.A. in behavioral sciences in 1978 and a B.S. in soil science at California State Polytechnic Institute at Pomona before beginning graduate study at Purdue University in 1983. His M.S. research work involves bioassay diagnoses of aluminum toxicities in surface and subsoil horizons. A low pH associated with aluminum toxicity reduces root length and the uptake of several elements, including phosphorus. For the future, Mr. Karr hopes to be involved in soil fertility research and teaching while keeping abreast of developments in related disciplines.

Gary A. Kruger was the top graduate in the College of Agriculture at the University of Saskatchewan in 1981, and now is working toward the M.S. degree in soil science. His research is on the significance of copper fertilization for wheat and barley production in Saskatchewan. The major emphasis will focus on proposing suitable diagnostic methods for identifying copper deficient soils in the province. Mr. Kruger hopes to work in the fertilizer extension field as an agronomist or research officer.

Jed Myers completed his M.S. degree at Ohio State University in 1981 and is now working toward the Ph.D. degree. He is investigating the chemical, mineralogical, and biological aspects of fixation of exchangeable magnesium when acid soils are limed. For the future, Mr. Myers would like to teach and do research in soil fertility and soil chemistry at the university level. He hopes to study certain implications of conservation tillage on nutrient availability.

Richard J. Roseberg graduated with a B.S. degree in soil science from Oregon State University in 1980 and now is in a graduate program for the M.S. degree in soil fertility. He is studying the effects of chloride fertilizer upon nitrification and related soil factors, and the resulting influences upon the severity of take-all root-rot of wheat. He is preparing for a career in agriculture to help improve production capabilities for growers.

The Fellowship winners were chosen by a committee of five members: two from the PPI staff and three from the PPI Advisory Council. Dr. J. Fielding Reed, President (Retired) of PPI and Chairman of the Selection Committee, added this comment on the awards: "Beyond the monetary value of these Fellowships, we must continue to encourage excellence and reward achievement in the agricultural sciences. This is our fifth year for the Fellowship Awards, and the response among outstanding graduate students has been very positive." ■

How 1983 Weather Hurt the Corn Crop

By Louis M. Thompson

THE SUMMER DROUGHT of 1983 was one of the four worst droughts of the past century for the Corn Belt as a whole. Our worst droughts have occurred when we have had above normal temperature and below normal rainfall in both July and August.

The weather variables used in this analysis are: (1) preseason precipitation (September through June); (2) July rainfall; (3) August rainfall; (4) June temperature; (5) July temperature; and (6) August temperature. **Table 1** shows the departures from normal for 1983 compared to 1936, which was the most severe drought year on record. Normal in this comparison is the average since 1891. Preseason precipitation was much below normal in all five states in 1936 and above normal or near normal in all five states in 1983. The rainfall in July was lower in all states in 1936 compared to 1983. However, rainfall in August was lower in 1983 than in 1936 in four of the five states. A significant feature of 1983 was that the season started off very well but became warmer and drier toward the end of the season.

For comparison of drought years I have used a set of coefficients that are common to all five of the Corn Belt states. They were developed from multiple curvilinear regression analysis[1] The coefficients are very useful in estimating the effects of departures from normal weather for recent levels of technology. For this comparison it is assumed that the level of technology would have been the same for all years.

Table 1. Departures From Normal Weather and Resulting Corn Yields.*

	Illinois		Indiana		Iowa		Missouri		Ohio	
	1936	1983	1936	1983	1936	1983	1936	1983	1936	1983
Preseason Precip.	−8.04	+7.36	−9.80	+1.40	−3.46	+7.04	−10.34	+5.07	−6.32	−0.32
June Temp.	+0.70	+0.20	+0.52	+0.22	+0.35	+0.55	+2.94	−1.65	+0.75	−0.35
July Rain	−2.35	−1.63	−2.05	−1.31	−3.22	−1.22	−2.15	−1.85	−0.84	−0.22
July Temp.	+7.30	+3.10	+6.18	+2.98	+8.93	+3.23	+7.32	+1.92	+3.58	+2.18
August Rain	−0.80	−1.02	−0.38	−0.98	−0.29	−1.38	−2.87	−2.16	+0.21	−1.07
August Temp.	+6.59	+4.79	+5.84	+4.24	+6.87	+6.47	+8.00	+5.60	+4.33	+3.33
Corn Yield	**24.0**	**81.0**	**25.5**	**74.1**	**20.0**	**88.5**	**10.5**	**49.6**	**33.0**	**81.0**

*Yield in bushels per acre, rainfall (precipitation) in inches, and temperature in Fahrenheit(F).

Dr. Thompson is Associate Dean Emeritus, College of Agriculture, and is in the Agronomy Department at Iowa State University.

(1)Thompson, Louis M. 1969. Weather and Technology in the Production of Corn in the U.S. Corn Belt. Agronomy Journal 61:453-456.

Table 2. Departures in Yield From That Expected with Normal Weather.*	1901	1936	1947	1983
Illinois	−20.1	−40.9	−22.1	−23.6
Indiana	−26.2	−35.0	−10.5	−17.9
Iowa	−26.5	−50.3	−31.8	−25.6
Missouri	−28.5	−47.3	−19.9	−24.7
Ohio	−15.6	−16.9	− 6.6	− 9.4

*Yield in bushels per acre.

Table 2 shows a comparison of departures from normal yields for the four worst drought years of this century. The summer of 1936 was the warmest summer while the summer of 1901 was the second warmest summer of this century. The drought in 1947 did not start until mid-July. The preseason precipitation was very much above normal in 1947.

Other major droughts were in 1934, 1954, 1955, 1974 and 1980. Missouri suffered more from drought in 1934, 1954 and in 1980 than in 1983. Indiana and Ohio suffered more from drought in 1934 than in 1983. The fact that the drought in 1983 was so widespread accounts for its prominence. The drought in 1974 was a midsummer drought. Yields were reduced by excessive rain in May and June, a short drought and early frost.

Another index of drought for the Corn Belt is the cumulative degrees above 90 during July and August. In 1936 the cumulative degrees above 90 at Lafayette, Indiana, totaled 408 for July and August, while in the same period in 1983 the total was 193. In July 1936 there were 15 days with temperatures above 100, while in July 1983 there were four days with temperatures over 100 at Lafayette.

There was a popular notion in the early 1970s that weather was no longer a major factor in corn production with modern technology. We had just gone through eighteen years of very little weather variability and no widespread drought. There is now a growing awareness that weather is becoming more variable, and that we are indeed quite vulnerable to the damages of drought.

The calculations presented in **Table 2** indicate how damaging another drought like 1936 would be to our corn supply. Finally, it should be recognized that the coefficients tended to underestimate the damage of drought rather than overestimate the damage in 1983. The coefficients represent average effects of weather on corn yields over the past 25 years. ■

On the Lighter Side

A rowdy foursome gathered on the first tee of the golfcourse with considerable discussion about each other's talents. The first golfer stepped up, took a mighty swing, and missed the ball by some distance.

"Darn," he exclaimed. "This course is at least four inches lower than the one I usually play."

* * * * * *

Women have to do everything twice as well as men to be thought half as good. Luckily, this is not difficult.

* * * * * *

A fisherman who had been caught by the game warden for exceeding his limit on black bass was taken to the local county courthouse, where he readily admitted his guilt.

"That'll be twenty-five dollars per fish and court costs," pronounced the judge.

After paying the fine, the angler approached the judge and cheerfully asked, "And now, Your Honor, I'd like several copies of the court record to show my friends."

P & K Provided "Drought Insurance" for Corn on High Testing Soils

By Ivan Wikner

IN 1980, a 5-year study was begun by the Pioneer Agronomy Service Department at Johnston, Iowa to evaluate the addition of phosphate and potash on soils already testing very high in fertility. Drought developed in 1980 . . . and again in 1983. This focused attention on how applied P and K in combination with nitrogen (N) could increase the number of kernels pollinated in the face of moisture stress. Also, after 2 good-weather-crop years in 1981 and 1982, the yield response from additional N and P and K varied significantly from the drought-year responses. As a result, Pioneer agronomists have started to classify research environments by weather conditions and are studying the fertilizer interactions associated with stress-years.

The research plots located at the Pioneer Breeding Station at Johnston, Iowa have been in corn for at least 30 years. The plot area has received annual buildup NPK rates for corn breeding and management research tests. Consequently, this high soil fertility background raised questions about the need for continued use of P and K rates. **When the experiment was established in the fall of 1979, soil tests were taken and the plot area was divided, with half receiving no additional P and K (−PK) and the other half receiving 100 lb P_2O_5 and 120 lb K_2O/A (+PK) applied annually. Plots in both areas were treated with N rates of 0, 100 and 200 lb/A each year.** Four adapted hybrids were included in each split plot treatment to determine if hybrids reacted differently to the treatments.

Table 1. Soil test data. Pioneer Research, Johnston, Iowa.*

N Rates lb/A	Soil Test	PK Soil Analyses — (Iowa State University Lab) No PK Added (−PK) 1981	1982	1983	PK Added** (+PK) 1981	1982	1983
0	P	482	384	392	396	320	344
0	K	848	832	728	1074	890	816
100	P	—	408	416	—	328	272
100	K	—	952	760	—	964	744
200	P	456	384	384	456	400	380
200	K	895	896	720	1020	960	1064

*Initial soil tests (by A&L Lab): organic matter, 3%; C.E.C., 11 meq/100 g; P, 320 lb/A; K, 822 lb/A; soil texture, fine sandy loam.

** 100 lb P_2O_5, 120 lb K_2O.

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Soil Test Results

Soil tests were taken before the experiment started and after each crop was removed. In recent years, each plot has been sampled after the crop was removed.

Although the soil samples vary some from plot to plot, there has been no major depletion of the soil phosphorus or potassium level **(Table 1).**

Soils were analyzed for other elements, but tests were not considered significant to be included in this paper.

Weather Records

The weather records have been useful in confirming the pollination problems during 1980 and 1983 seasons **(Table 2).** In those years, drastic differences in silk emergence and drought stress were apparent among fertilizer treatments. The major component influencing grain yield was kernels pollinated, which were drastically reduced under drought-stress when additional fertilizer P and K were not applied . . . even though P and K soil test levels were very high.

Table 2. Record of rainfall and high temperatures, Johnston, Iowa.

Growing Season	Rainfall, inches	Days above 90°F	Days above 100°F
1980 — May	3.47	0	0
June	4.45	4	0
July	1.17	23	10
Aug.	5.60	10	0
Total	**14.71**	**37**	**10**
1981 — May	2.13	0	0
June	4.32	5	0
July	4.46	9	0
Aug.	7.06	2	0
Total	**17.97**	**16**	**0**
1982 — May	6.23	0	0
June	3.93	1	0
July	6.97	11	0
Aug.	4.66	5	0
Total	**25.00**	**16**	**0**
1983 — May	6.25	0	0
June	9.12	8	0
July	2.91	23	4
Aug.	3.16	24	6
Total	**21.44**	**55**	**10**

High temperatures in late June and early July have been the key factor affecting corn pollination. Both drought-years (1980 and 1983) had a similar pattern . . . starting during the early pollination period. Apparently, the early uptake of P and K was adequate when additional phosphate and potash were applied to help silking and pollination of more kernels. This relationship was critical during periods of high pollination-stress.

Corn Yield Results of Fertility Treatments

The yield data show very different response patterns to fertilizer, comparing drought-years with good weather-years. Therefore in analyzing the data, the yields have been grouped by environment and the averages and overall means are shown in **Table 3.** Proper use of fertilizer helps maximize profits or minimize losses.

Table 3. Actual yields and yield increase for N and PK rates.

	Corn Yield, bu/A								
	Avg. Drought Years			Avg. Good Weather Yrs.			4-Year Avg.		
N Rate	−PK*	+PK**	Increase	−PK	+PK	Increase	−PK	+PK	Increase
lb/A									
0	60	65	+ 5	133	135	+ 2	96	100	+ 4
100	79	105	+ 26	168	171	+ 3	123	140	+ 7
200	69	124	+ 55	169	177	+ 8	119	150	+ 31
Max.	69	98		157	161		113	130	
Response	+19	+59		+36	+42		+24	+50	

* No PK.

** 100 lb P_2O_5, 120 lb K_2O.

Nitrogen Response

Nitrogen produced excellent yield responses with the greatest increase when additional P and K was applied annually — especially in drought-years. In the absence of added P and K in drought-years, yields decreased or were similar at the 200 lb/A N rate. The economic analysis in **Table 4** shows that it was profitable to use nitrogen across environments, but P and K were necessary in dry years to obtain a profitable response at the 200 lb/A N rate.

Table 4. Economic analysis of fertilizer applications.

		Drought Years				4-Yr. Avg. Drought & Good Yrs.			
N Rate		Yld. Inc.	Fert. Cost	Corn $3/bu	Return Over Cost	Yld. Inc.	Fert. Cost	Corn $3/bu	Return Over Cost
lb/A		bu/A	$/A/Year			bu/A	$/A/Year		
0	+PK	5	$42	$ 15	−$27	4	$42	$ 12	−$30
100	+PK	26	68	78	10	17	68	51	− 9
200	+PK	55	94	165	71	31	94	93	− 1
PK Rate	N								
No PK	100#	19	$26	$ 57	$31	27	$26	$ 81	$55
No PK	200#	9	52	27	−25	23	52	69	17
100-120	100#	40	$68	$120	$52	40	$68	$120	$52
100-120	200#	59	94	177	83	50	94	150	56

P and K Response

The response of applied P and K has been greatest in the drought-years. The greatest yield increases to phosphate and potash were found with increasing rates of N: 26 bu/A response with 100 lb N and 55 bu/A increase with 200 lb of N. This indicates a positive interaction of 50 bu/A between the N and PK treatments under drought conditions. In the good-weather years N alone produced a maximum response of 36 bu/A, but the response to N was increased to 42 bu/A with the PK treatment. The economic analysis for P and K indicates that the application was profitable in dry years when at least 100 lb of N was used. When averaged across the 4-year period, the breakeven point was at 200 lb of N with P and K present. Therefore, losses were minimized by the treatment.

Hybrid Response

The hybrids tested in the experiment have good drought tolerance records, were full season for the area, and represent different genetic backgrounds. The analysis of variance for fertility x hybrid interactions show only 1 of 16 interactions as being significant. This indicates that hybrids are performing in a similar way under the drought or good conditions. If non-stress tolerant hybrids had been used, barrenness could have caused even more variable yields and interactions in severe drought environments.

Discussion of Results

This progress report covers 4 years of a study that will continue to accumulate additional data for different environmental conditions. In 1984, the P and K were applied in a band placed 8 inches to the side of the row and 4 inches deep. In prior years, the P and K were plowed under or disked in with tillage.

This study identifies silking and silk delay as critical factors closely associated with NPK balance, barrenness, and yield. It also supports the importance of fertilizer to early NPK uptake and interrelations in corn plants prior to tasseling and silking, as drought-stress in 1980 and 1983 started during the critical pollination period. Results suggest that low yields during drought-years may be related to low P and K uptake prior to pollination, even though soil test levels indicate very adequate availability, and the balance of P and K with N.

The major surprise in this experiment was that very high soil test levels of phosphorus and potassium apparently did not supply enough P and K to balance the effect of added N. Either the soil P and K were not readily available due to dry soil conditions, or the reversion to non-available forms was greater than expected. The added fertilizer, phosphate and potash, apparently provided sufficient concentration for good nutrient uptake during early growth.

Another interesting way to look at these data is from the standpoint of the effects of N, PK and NPK combinations on moisture use efficiency for the rainfall that was recorded during the growing season. The efficiency indexes for the various fertilizer treatments are shown in **Table 5.**

Table 5. Water use efficiency for seasonal rainfall as related to fertilizer treatments.

	Growing Season Rainfall	Rainfall Efficiency — bu/inch of rainfall					
		– PK			+ PK		
		0	100 N	200 N	0	100 N	200 N*
1980	14.7	4.17	3.14	2.89	5.00	7.57	8.72
1981	18.0	9.66	9.66	9.61	8.88	9.55	10.17
1982	25.0	3.68	6.44	6.66	3.72	6.80	6.80
1983	21.4	2.52	5.09	4.30	2.52	4.71	5.23
Avg.	**19.8**	**5.01**	**6.08**	**5.87**	**5.03**	**7.16**	**7.73**

* N rates, lb/A

The balance of nutrients and its effect on kernels pollinated are dramatized by the efficiency index of bushels per inch of rainfall for the treatments in both the drought and the good years. In 1980, with 200 lb/A N and no added PK, the efficiency was only 2.89 bu/in. But with PK the efficiency increased to 8.72 bu/in. In the best year, with a combination of nutrients the index increased to over 10 bu/in.

These results may suggest that agronomists need to take a closer look at importance of annual application of P and K with possibly band placement to provide better availability of the P and K for early uptake by corn plants before pollination. ■

Irrigated Alfalfa: Potassium Deficiency in Semi-Arid Soils

By David W. James

ARID AND SEMI-ARID SOILS ordinarily have a large supply of readily available potassium (K) because natural precipitation rarely if ever leaches through the root zone. This is true in Utah's semi-arid valleys where native supplies of available K were quite high.

Irrigation and cropping practices are changing the picture, however. Potassium deficiency in Utah-grown alfalfa has been observed in recent years in widely scattered areas as evidenced by typical potassium deficiency symptoms and/or response to K fertilization. In every case where potassium deficiency in alfalfa has been observed the soils have been under continuous irrigation for 75 to 100 years. In addition, the irrigation waters used are low to very low (that is, less than 40 lb K/acre-ft.) of dissolved potassium.

A 3-year survey of irrigation water quality was recently concluded in Utah. Data from this survey were compared with a similar survey conducted in 1949 and 1950. Results from the two sampling periods indicate that irrigation water quality at a given sampling point has been essentially constant over time. Furthermore, irrigation waters in diverse areas of Utah are very low in dissolved K. For example, the K concentration of 25 widely scattered sample points, each representing original diversion irrigation waters, ranged between 0.02 and 0.12 meq K/L (liter) with a mean of 0.06 meq K/L. By original diversion we mean streams that have no irrigation return-flow. Return-flow is water that returns to the river drainage system from surface irrigation runoff or from water that has percolated through the soil which ultimately drains back into the river via an aquifer.

Table 1. Potassium content of irrigation water: concentration, pounds per acre-foot, and pounds per year at maximum ET.

meq K/liter (L)	lb K/acre-ft	lb K/year
0.01	1.1	2.7
0.05	5.3	13.3
0.10	10.6	26.5
0.15	15.9	39.8
0.20	21.2	53.1
0.25	26.5	66.3
0.50	53.1	132.6
0.75	79.6	198.9
1.00	106.1	265.3

(1) Assumes evapotranspiration potential is to 2.5 acre-feet/year and that exactly this amount of irrigation was applied.

Table 1 shows the relation between K concentration and pounds of potassium delivered to soil in irrigation water. It is evident from these data that the 25 water sources mentioned above contribute very little to soil/plant potassium needs. On the other hand, streams that receive irrigation return-flow contain larger amounts of dissolved potassium. **Table 2** shows water quality (K content) results from 2 such river systems. In general, increasing potassium content of water is associated with increasing levels of all salts such as sodium, magnesium, and calcium chlorides and sulfates. Potassium is not considered an important component of the water quality (salinity) equation so this element is generally ignored in water quality evaluations.

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DR. DAVID W. JAMES has identified nutrient deficiency in irrigated alfalfa in some areas of Utah.

Table 2. Potassium concentration of two river systems as related to sample site and degree of return-flow and dilution from tributaries.

River and sample point		K content meq/L
Bear River:	at Sage Junction	0.10
	at Lewiston	0.28
	at Cache Junction	0.26
	at Corinne	0.67
Sevier River:	at Panguitch	0.05
	at Kingston	0.11
	at Sevier	0.12
	at Salina	0.29
	at Mill Junction	0.22
	at Delta	0.34

A simple balance sheet of K inputs and outputs with irrigation and cropping shows that the net yearly loss in soil K reserves may be quite appreciable. For example, a well managed alfalfa crop will contain 2% or more of K on the dry basis. Thus, annual hay yields of 4, 6 or 8 tons/A will remove at least 160, 240 or 320 lb/A of K per year, respectively. Referring to **Table 1,** it is evident that high quality (low salinity) waters that contain less than 0.2 meq K/L contribute very little K to the soil/crop system.

It should be noted that the quantity of K supplied by irrigation depends on evapotranspiration (ET). In Utah annual ET demand ranges between 2 and 3 acre-feet of water, depending on elevation and length of growing season. The potential amount of K that will be added in a given irrigation water will depend on whether sufficient water has been applied to satisfy ET. If the amount of applied irrigation water is less than ET, then less than the maximum possible amount of K will be added. On the other hand, if the amount of water applied is greater than ET some K will pass through the root zone as leachate and the net amount of irrigation-applied K will be less than the maximum potential.

On balance, therefore, some Utah soils are being depleted of available K through cropping and to some extent, no doubt, from leaching. Potassium deficiencies are now being seen in coarse and medium-textured soils where irrigation waters contain less than 0.15 meq K/L, or 16 lb K/acre-ft. It is apparent, if Utah-grown alfalfa and other crops are to be maintained at top production, that K fertilization will become a regular practice in some areas within this state. This represents a new concept and new management practice for farm operators to become accustomed to. Irrigation water analysis should be used in conjunction with diagnostic soil testing to manage K soil fertility. In Utah, K deficiency in alfalfa correlates with extractable K levels of less than 100 ppm. ■

Oregon's Columbia Basin

Fertilizer Response of Reduced Tillage Wheat

By Hugh Gardner and Francis Nibler

BECAUSE FARMERS have adopted conservation tillage practices there is a need to study the fertilizer management of crops grown in reduced tillage systems. Reduced tillage is receiving considerable attention on Oregon's Columbia Plateau where sloping terrain and silty soils combine to create a serious erosion hazard. Many grain growers in this region have adopted reduced tillage soil management practices.

Two tillage systems being used to reduce soil erosion are trashy fallow and continuous cropping. These soil management systems replace a two year "black" fallow/crop rotation in which the fallow operation where crop residue was plowed down created a serious erosion problem on sloping land. Current fertilizer recommendations are based on soil test calibration research conducted under "black" fallow rotation management.

A series of fertilizer experiments with Stephens winter wheat was conducted on the Columbia Plateau in 1982-1983. These experiments were located in fields where trashy fallow or recrop management was being practiced. The fields were non-irrigated (10-20-inch rainfall zone), soils varied from 18 inches to over 6 feet in depth and from sandy to silty loam in texture. The plots were seeded using shank openers and coulters and a 12-inch row spacing.

The fertilizer treatments were applied in October when the plots were seeded. Ammonium sulfate banded 2 inches into the soil midway between the rows was used as the N and S source (except for the zero S treatment where urea was used as the N source). Phosphorus was banded close to the seed using 10-34-0 solution at the rate of 50 lb/A of material (17 lb P_2O_5).

Nitrogen applications resulted in substantial grain yield responses at all locations **(Figures 1 & 2).** For the shallower soils, (less than 36 inches) the average maximum

Figure 1. Wheat Yield Increase from Nitrogen-Shallow Soils.

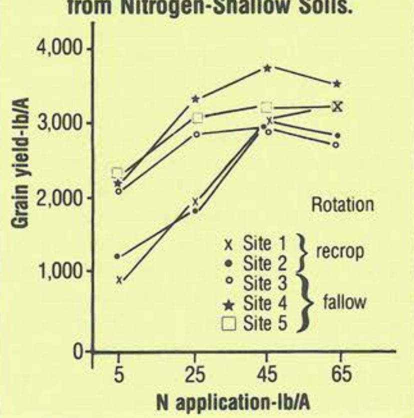
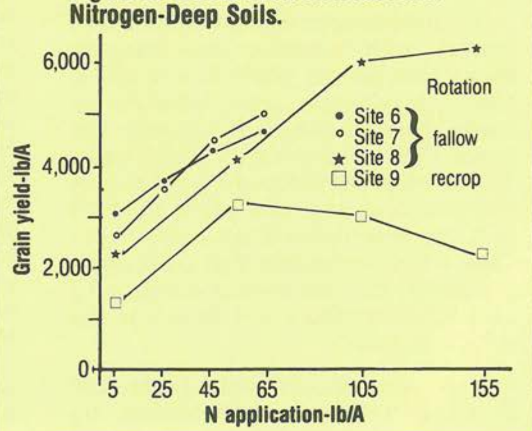


Figure 2. Wheat Yield Increase from Nitrogen-Deep Soils.



The authors are with the Department of Soil Science, Oregon State University.

yield increase resulting from N fertilizer was 1,573 lb. of wheat/A **(Figure 1)**. At 4 of 5 locations the 65 lb N/A application failed to increase yields over the 45 lb/A N rate. The average maximum grain yield increase from N fertilizer for the two recrop locations on shallower soils was 2,152 lb grain/A (Sites 1 & 2, **Figure 1**) and for the three trashy fallow fields the increase from N fertilizer averaged 1,186 lb grain/A (Sites 3, 4 & 5). Nitrogen fertilizer response on the shallower soils, therefore, was greater with recrop wheat than wheat grown on trashy fallow.

For the deeper soils (> 66 inches) the average maximum grain yield increase from N fertilizer was 2,621 lb/A **(Figure 2)**. In the single recrop field on the deeper soils (Site 9) the yield increase from N fertilizer was 2,174 lb grain/A compared to an average increase of 2,770 lb/A for the other 3 sites on deeper soils. Two experiments on deeper soils received higher rates of N application **(Figure 2,** Sites 8 and 9). At Site 8 in a trashy fallowed field N fertilizer increased yield by 4,524 lb grain/A compared to the 2,174 lb increase recorded for Site 9 which was located in a recropped field. The higher N rates of 105 and 155 lb/A depressed yields below the 65 lb/A rate at the recropped location. These results indicate that on deeper soils which can store comparatively large amounts of water that higher yields and greater N responses are realized from trashy fallowed fields than recrop fields.

Significant grain yield increases to P fertilizer were recorded at 2 locations (Sites 2 and 8, **Figure 3**). Site 2 had a shallower soil (20 inches) and was a recropped field with a low P soil test value of 6 ppm (Olsen $NaHCO_3$). Site 8 had a deep soil (> 72 inches) and was a trashy fallowed field with a moderate P soil test (13 ppm). Significant yield responses to P were not recorded at 7 locations where P soil test values ranged from 6 to 20 ppm.

Sulfur fertilizer increased grain yields at 2 locations (Sites 2 and 8, **Figure 4**). These are the same locations where responses to P fertilizer were recorded. Site 2 was on a shallow soil in a recropped field and Site 8 on a deep soil in a summer-fallowed field. Wheat yield increases from S fertilizer on deeper, high yielding soils have been recorded in previous field trials in this region. Spring soil test values for sulfate-S in the 0-24-inch soil depth in the plots not fertilized with S were low for both of the S responsive locations equaling 1.3 and 0.6 ppm for Sites 2 and 8, respectively. Soil test values for sulfate-S for the other locations where significant grain yield responses to S fertilizer were not recorded ranged from 0.6 to 5.3 ppm. ■

Figure 3. Wheat Yield Increase from P_2O_5.

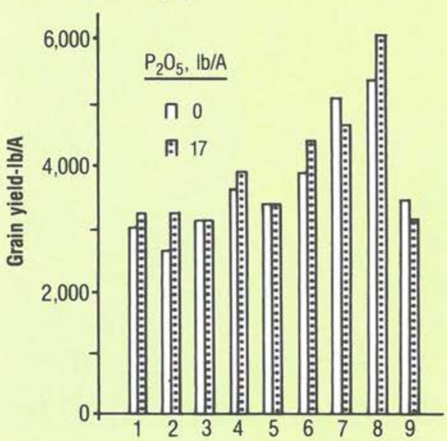
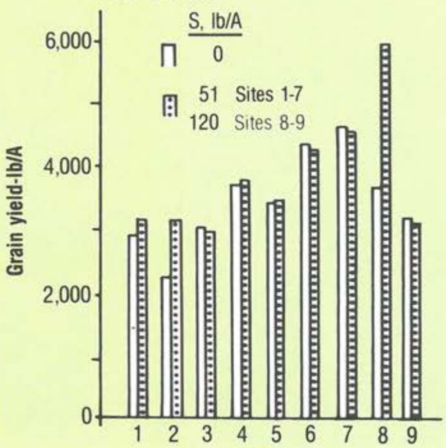


Figure 4. Wheat Yield Increase from Sulfur.



Rotation with Soybeans Increases Corn and Grain Sorghum Yields

By Mark M. Claassen and David E. Kissel

CORN AND SORGHUM often yield more in rotation with soybeans than when grown continuously. Part of the benefit for these grain crops has been attributed to a nitrogen (N) contribution by the soybeans. However, the amount of N that soybeans supply has remained a question.

Studies in northeast Kansas on Grundy silty clay loam soil were initiated in 1979 to gain additional information on N utilization by corn and sorghum in corn-soybean, continuous corn, sorghum-soybean, and continuous sorghum cropping systems.

Corn and sorghum studies were conducted on adjacent sites. Prior to planting each year, 5 rates of N from zero to 200 lb/A were applied and incorporated by tillage. Phosphorus (P) was banded with the planter at the same rate on all plots in a given year. Annual rates of P_2O_5 varied from 37 to 46 lb/A.

Initial soil test values on the experiment sites were: organic matter, 2.5%; pH, 6.0; available P, 25 lb/A; and exchangeable K, 453 lb/A. Corn (Northrup King PX 74 or O's Gold SX 3344) was planted in late April or early May. Grain sorghum (Prairie Valley 677 GR, Pioneer 8626, or Funk's G-550) was planted in early June, except for 1982, when wet weather caused a 2-week delay.

Table 1 shows yield data for corn for 1980, 1982, and 1983. Soybeans preceding corn in the rotation averaged 42, 45 and 30 bu/A respectively for these years. Because of drought, little or no corn grain was produced in 1980 and 1983. Consequently, yields were measured as total forage dry matter (DM). In 1980 corn DM yields in zero-N plots did not differ significantly between corn after soybeans and continuous corn. When averaged across N rates, DM yields in 1980 were slightly greater (0.2 ton/A) for continuous corn because of slower initial develop-

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Table 1. Crop sequence and N fertilizer effects on corn.*

Crop sequence	N rate lb/A	Yield tons/A	Yield bu/A	Leaf composition N (%)	Leaf composition P (%)	Leaf composition K (%)	N** uptake lb/A	Soil N*** ppm
Corn after soybeans	0	2.43	81	1.69	.246	1.85	58	11
	40	2.39	106	2.08	.248	1.77		
	80	2.46	138	2.34	.256	1.67		
	120	2.53	145	2.36	.271	1.57		
	200	2.95	143	2.53	.274	1.53		
Continuous corn	0	1.83	50	1.54	.329	1.89	38	10
	40	1.99	60	1.63	.263	1.84		
	80	2.20	97	1.99	.275	1.78		
	120	2.36	112	2.33	.278	1.62		
	200	2.24	135	2.54	.286	1.60		
Means:								
Crop sequence								
Corn after soybeans		2.55	123	2.20	.259	1.68		
Continuous corn		2.17	91	2.00	.286	1.75		
Nitrogen rate	0	2.13	65	1.63	.288	1.87		
	40	2.19	83	1.85	.255	1.81		
	80	2.33	118	2.17	.266	1.73		
	120	2.42	129	2.35	.275	1.60		
	200	2.73	139	2.53	.280	1.57		

* Powhattan, KS 1980, 82, 83. Yield as total forage dry matter (tons/A) averaged for drought years (80, 83) and as grain for 1982. Leaf composition average 1980, 83.

** Average N in stover and grain 1980, 82.

*** Average concentration in top 2 feet of soil prior to beginning of growing seasons.

ment associated with seedbed conditions and slightly less subsequent moisture stress. DM yields for 1983 in zero-N plots were nearly 2.5 times greater for corn after soybeans than for continuous corn.

Forage yield of corn after soybeans indicated no significant response to fertilizer N in either of the dry seasons, except for the 200 lb N/A rate in 1983. Continuous corn, on the other hand, produced approximately 0.4 ton/A more with 120 lb N/A in 1980 and 0.5 ton/A more DM with N rates of 80 lb/A or more in 1983.

Both crop sequence and N rate significantly affected corn grain yields in 1982. In zero-N check plots, corn after soybeans produced 31 bu/A more than continuous corn. Interestingly, this yield difference between the crop sequences was maintained when yields were averaged across all N rates. With 80 lb N/A, the yield of corn after soybeans was approximately equal to the maximum continuous corn yield with 200 lb N/A.

Increases in corn leaf N levels resulted from rotation with soybeans as well as from fertilizer N. However, total nitrogen uptake by plants without fertilizer N did not account for much of the difference in yield attributable to soybeans in the crop rotation. Average N uptake in 1980 and 1982 by plants in zero-N plots showed that soybeans contributed 20 lb N/A to the stover plus grain of the following corn crop. Year-to-year variation in this value reflected moisture availability.

Under the conditions of these studies, grain sorghum showed a large and con-

Table 2. Crop sequence and N fertilizer effects on grain sorghum.*

Crop sequence	N rate lb/A	Yield bu/A	Leaf composition N	P	K	N** uptake lb/A	Soil N*** ppm
			----------%----------				
Sorghum after soybeans	0	82	2.41	.269	1.45	84	13
	40	92	2.66	.274	1.45		
	80	87	2.81	.286	1.49		
	120	87	2.90	.284	1.50		
	200	89	2.96	.284	1.45		
Continuous sorghum	0	44	2.11	.275	1.46	42	11
	40	56	2.29	.272	1.48		
	80	77	2.53	.277	1.48		
	120	83	2.80	.286	1.52		
	200	86	2.96	.302	1.47		
Means:							
Crop sequence							
Sorghum after soybeans		87	2.75	.279	1.47		
Continuous sorghum		69	2.53	.282	1.48		
Nitrogen rate	0	63	2.26	.272	1.46		
	40	74	2.47	.273	1.47		
	80	82	2.67	.282	1.49		
	120	85	2.17	.285	1.51		
	200	88	2.96	.293	1.47		

* Powhattan, KS 1980-83.
** Average N in stover and grain 1980-82.
*** Average concentration in top 2 feet of soil prior to beginning of growing seasons.

sistent yield response to rotation with soybeans **(Table 2)**. During the four consecutive years, sorghum in the rotation followed soybeans which had yields of 41, 22, 42, and 33 bu/A, respectively. In zero-N check plots sorghum after soybeans produced from 26 to 51 bu/A more than continuous sorghum over the 4-year period. When averaged across all N rates, these yield differences ranged from 14 to 26 bu/A. In terms of fertilizer response, yields of sorghum after soybeans in 1980 were maximized with 40 lb N/A at a level 24 bu/A above that of the highest continuous sorghum yield, attained with 120 lb N/A. In the succeeding years, yields of grain sorghum in the two crop sequences were brought to about the same level (near optimum) with sufficient N fertilizer. Over the period, 40 to 80 lb N/A for sorghum after soybeans was nearly equivalent to 120 or more lb N/A for continuous sorghum.

At low N rates leaves of continuous sorghum had distinctly lower N levels than those of sorghum after soybeans. From 40 to 80 lb N/A were required to eliminate this difference in leaf N associated with crop sequence. N uptake data obtained from stover and grain analyses revealed a contribution of 29 to 51 lb N/A from soybeans.

In summary, the N contribution of soybeans to the following row crop appeared to be a larger part of the soybean benefit in the case of grain sorghum than in the case of corn. For either corn or grain sorghum production, however, inclusion of soybeans in the crop sequence provided opportunity for higher crop yields and/or lowered rates of N fertilizer. ■

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Is Technology Ruining Our Soil?

ONCE AGAIN we hear the battle cry. This one is for the never ending fight against loss of our most valuable asset – our soil. It's an old war – fought throughout the centuries – indeed, fought and lost in many parts of the world.

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