NEWS & VIEWS

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Fertilizer Contributions to Crop Yield

SOME have estimated that nutrient inputs are responsible for between 30 and 50 percent of crop yield. Making these estimates presents significant challenges. Certain assumptions are required regardless of the approach taken. One difficulty that arises is that crops respond differently to different fertilizer nutrients. For example, corn response to nitrogen (N) fertilizer is much greater than that of legumes such as soybeans or peanuts. This effort is further confounded by many other factors such as variable soil fertility levels, climatic conditions, and changes in production practices that affect nutrient use efficiency. Nevertheless, meaningful estimates of the contribution of inorganic fertilizer to crop yield can, and have been made.

Researchers at Texas A&M University and the Tennessee Valley Authority investigated the impact of chemical use reduction on yields for eight major crops in the U.S. The investigators analyzed the impact of eliminating the use of pesticides (herbicides, insecticides, and fungicides) and inorganic N fertilizer on corn, cotton, rice, barley, sorghum, wheat, soybean, and peanut yields. Other crop nutrients were not taken into account. The estimated effect of eliminating N fertilizer alone (i.e., no pesticide elimination) on U.S. crop yields is shown in **Table 1**.

Table 1. Estimated effect of eliminating N fertilizer on U.S. crop yields.

	Yield[1], bu/A or lb/A		
Crop	[2]Baseline	Without N	Reduction, %
Corn	122	72	41
Cotton	679	427	37
Rice	5,500	4,000	27
Barley	47	38	19
Sorghum	69	56	19
Wheat	32	27	16
Soybean	34	34	0
Peanut	2,281	2,281	0

[1] Crop yields are in bu/A for corn, barley, sorghum, wheat, and soybean; lb/A for cotton, rice, and peanut. [2] Baseline yields taken from 1987 USDA-ERS report.
Source: Smith et al., 1990.

Average U.S. corn yield was predicted to decline by 41 percent without N fertilizer. In other words, N fertilizer was responsible for 41 percent of corn yield. The elimination of all pesticides plus N fertilizer resulted in an estimated 53 percent decline in corn yield. The elimination of N in cotton production resulted in an estimated yield reduction of 37 percent, the largest of any single input group analyzed. The average estimated reduction in yield from elimination of N fertilizer of the six non-leguminous crops was 26 percent.

One approach to estimating the portion of crop yield attributable to fertilizer is to select studies for major crops where zero fertilizer controls have been employed and calculate the portion of yield attributable to fertilization. At Oklahoma State University, scientists have studied wheat fertility since the late 1800s. The Magruder Plots, established in 1892, are the oldest continuous soil fertility wheat research plots in the Great Plains, and are among the oldest in the world. As one would expect, the fertility treatments have changed since the plots were established, with annual inorganic fertilizer applications commencing in 1930. The inorganic N source was sodium nitrate ($NaNO_3$) from 1930 to 1946, when it was changed to ammonium nitrate (NH_4NO_3). Nitrogen rates have ranged from 33 to 60 lb N/A. The early inorganic phosphorus (P) source was ordinary superphosphate [0-20-0-12 sulfur (S)]. It was replaced by triple superphosphate (0-46-0) in 1968. The P rate throughout the study has been constant at 30 lb P_2O_5/A. **Figure 1** shows that when averaged over 71 years, N and P fertilizer have been responsible for 40 percent of wheat yield.

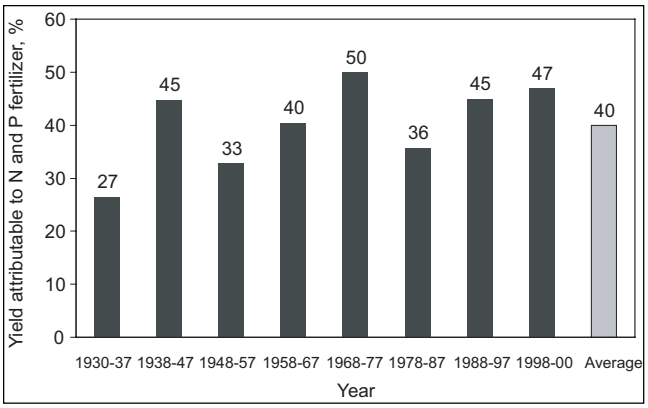
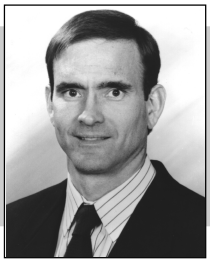


Figure 1. Wheat yield attributable to inorganic N and P fertilizer from N+P treatments from 1930 to 2000 in Oklahoma State University Magruder plots.
Source: OSU Soil Fertility Research Highlights, 2000.



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Another long-term study is being conducted at the University of Illinois. Various crops, rotations, and fertility treatments have been evaluated in the well-known Morrow Plots since 1876. Early fertility treatments included manure, rock phosphate, bone phosphate, and limestone. In 1955, commercial fertilizer treatments were imposed that combined N from urea, P from superphosphate, potassium (K) from muriate of potash, and lime. An evaluation of grain yields from continuous corn (**Figure 2**) from the no fertilizer control and the N+P+K+lime treatment revealed that, on average from 1955 to 2000, 57 percent of yield was attributable to the fertilizer+lime treatment.

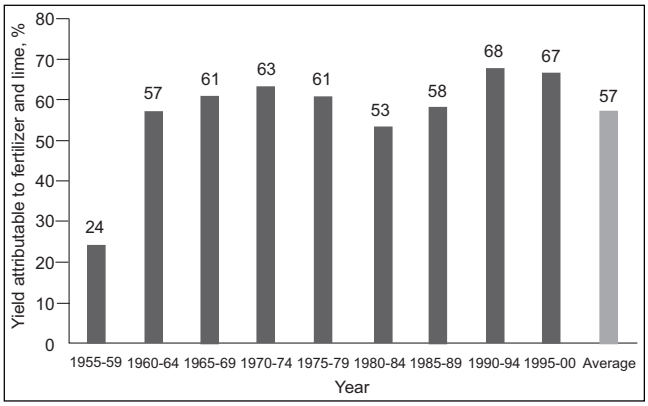

Figure 2. Continuous corn yield attributable to N, P, and K fertilizer and lime over 46 years, University of Illinois Morrow Plots.
(From personal communications with Harold Reetz.)

A long-term irrigated study in western Kansas has examined the effect of various N rates (0 to 200 lb N/A in 40 lb increments) and P fertilization (0 and 40 lb P_2O_5/A) on yields of corn and grain sorghum. Over 40 years (1961 to 2000) of this study, N and P fertilizer on average produced 44 percent of corn yield and 31 percent of sorghum yield. The data presented in **Table 2** summarize the 40-year average yields for both crops for each fertility treatment and percent of yield attributable to fertilization.

Table 2. Effect of N and P fertilizer on 40-year average (1961 to 2000) irrigated corn and grain sorghum yields and percent yield attributable to fertilization in western Kansas.

Fertilizer applied, lb/A		Grain yield, bu/A		Yield due to fertilizer, %	
N	P_2O_5	Corn	Sorghum	Corn	Sorghum
0	0	68	70	—-	—-
0	40	72	72	5	3
40	0	102	90	33	22
40	40	119	106	43	34
80	0	116	102	41	31
80	40	145	113	53	38
120	0	117	98	42	29
120	40	160	118	57	40
160	0	124	102	45	31
160	40	169	120	60	42
200	0	127	105	46	33
200	40	169	121	59	42

Source: Kansas Fertilizer Research, Schlegel, 1990, 1991, 2000.

The information in **Table 2** clearly illustrates the importance of balanced fertility in crop production. However, a more realistic approach to estimating the amount of yield attributable to fertilizer would be to examine the contribution at optimum rates of N and P. The economic optimum N rate for corn in this study was 160 lb/A. In most years for sorghum, it was 80 lb/A. Phosphorus fertilizer (40 lb P_2O_5/A) was necessary to maximize profit for both crops. The 40-year averages for percentage of yield attributable to fertilizer at the economic optimum rates for N and P for corn and grain sorghum were 60 and 38 percent, respectively.

The data from the long-term studies discussed herein represent 157 years of crop production. Although significant variability in crop response to fertilizer inputs occurs among crop species, soil conditions, climate, and other factors, these data and the results of the chemical use reduction investigation tend to support the generalization that somewhere between 30 and 50 percent of crop yield is attributable to nutrient inputs. ■

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