High Yields, High Profits, and High Soil Fertility

By B.C. Darst and P.E. Fixen

Consider the fact that by the year 2025 the per capita land base for world food production will be less than half what it was in 1965 (**Table 1**)...the result of more than a doubling of population, while land in crop production increases only slightly.

Imagine a highway of cereal grains circling the Earth at the equator. It is 8.3 feet thick and 66 feet wide. It represents the amount of production required to feed the world population for one year. Further, it must be completely reproduced each year and another 650 miles added... **just to feed the additional humans born that year.**

> "Use more and better machinery, plant the best seeds...cultivate effectively, and apply the kind and amount of commercial fertilizer that will produce the highest yields to reduce costs per unit..."
>
> *Southern Cultivator,* 1870

These are tough times for agriculture. Farmers are faced with low commodity prices. Fertilizer producers are shutting down or significantly curtailing production. Recovery from the economic meltdown in Asia is starting, but is slow. Western Europe and other parts of the world are backing off buying genetically enhanced crops. Why worry about growing more to feed a growing world population when farmers are being paid so poorly for what they are already producing? Farmers are in an economic squeeze, and answers don't come easy.

A recent headline in the *Southwest Farm Press* read "Good yields take the sting out of low prices." The headline emphasizes the impact low commodity prices are having on the farm economy. Input costs continue to rise while prices farmers receive sometimes resemble those of the 1970s. What can be done to ease the effects of the current economic downturn? Should farmers cut costs, turn on the cruise control, and let yields fall where they may? Such a management philosophy doesn't make sense, even in the short-term, much less when one looks to the future health of agriculture.

We all know that agriculture is a cyclic industry, controlled largely by outside forces. It is now at a low point in the cycle...things are bound to get better. While that doesn't make

TABLE 1. Arable land available for agricultural production.

Year	Arable land, A/person
1965	1.14
1980	0.84
1990	0.74
2000 (projected)	0.62
2025 (projected)	0.49

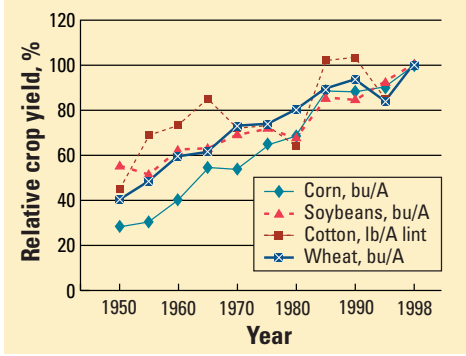

Figure 1. Relative yields of corn, soybeans, wheat, and cotton.

the situation any easier to accept, it does provide some perspective. It points critically to the need for high yield, high efficiency crop production. In 1984, the late Dr. J. Fielding Reed wrote, "The U.S. farmer will become more involved with the world food picture. Whatever farm programs evolve, the concept of maximum economic yield (MEY) is a sound principle...producing at the yield level that results in the least cost per unit of production."

High yields and low unit production costs give farmers the best chance to make a profit when prices are low. They also allow farmers to make the most profits when prices are higher. High yields mean more than higher profits in any given crop year. They are indicative of management that promotes sustainability... that is protective of the environment...and that makes most efficient use of purchased inputs such as fertilizers through sound nutrient planning.

In 1987, Dr. Reed said, "Maximum economic yield neither creates nor cures a world farm crisis. But, whatever the situation with regard to farm program, surplus, price, or exports, increasing production efficiency should be a part of the solution. Can anyone honestly disagree with that concept?" The quote at the beginning of this article, first published 130 years ago, and Dr. Reed's mid-1980s writings are still applicable today...and take us back to the basic principle that high, efficiently managed yields pay. Dr. Reed was correct: It would be difficult to honestly disagree with that concept.

The third part of the title of this article...high soil fertility...is an under-girding support of sustainable high yield crop production. The relationship among high yields, high profits, and high soil fertility is undeniable and well documented.

Yield trends for corn, cotton, soybeans, and wheat in the U.S. for the last 50 years, as shown in **Table 2**, have moved up dramatically and are reflective of increases in food and fiber production in general. **Figure 1** shows the same data plotted as relative yields for each crop, with the 1998 crop year being set at 100 percent. Many factors...mechanization, hybridization, development of the pesticide industry, improved farmer management...have contributed to these yield increases.

Efficient crop fertilization and nutrient management are also integral to the production of high yields. **Table 3** shows trends in nitrogen (N), phosphorus (P), and potassium (K) consumption in the U.S., 1950-1998. The growth in nutrient use closely parallels increases in crop yields, as would be expected. It is interesting to note, however, that even though NPK use leveled off beginning about 1980, crop yields continued to climb. One obvious conclusion to be drawn from this comparison is that farmers are making more efficient use of fertilizer nutrients. **Figure 2** verifies that conclusion. It shows that NPK use efficiency on corn has been increasing for the last 20 years. That's good news for the

TABLE 2. Corn, cotton, soybeans, and wheat yields in the U.S., 1950-1998.

	Yield			
Year	Corn, bu/A	Cotton lint, lb/A	Soybeans, bu/A	Wheat, bu/A
1950	38	269	22	17
1955	42	417	20	20
1960	55	446	24	26
1965	74	527	25	27
1970	72	438	27	31
1975	86	453	29	31
1980	91	404	27	34
1985	118	630	34	38
1990	118	634	34	40
1995	114	537	35	36
1998	134	618	39	43

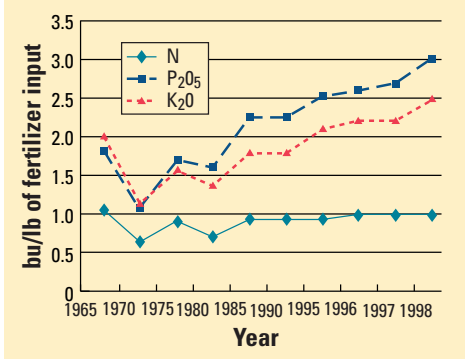

Figure 2. Corn nutrient use efficiency.

environment as well as the farmer and the consumer.

High, profitable yields also depend on proper nutrient balance. It is critical to look at total crop nutrient requirements when planning a production system and put together a nutrient management plan that meets those requirements. For example, N management doesn't depend solely on meeting the crop's N requirements. Rather, it includes considerations for other nutrients...and other management inputs...as well.

Figure 3 shows that soil K fertility has a significant impact on corn yield potential as well as N use efficiency. When soil test K was low (160 and 200 lb K/A), 320 lb N/A were required to produce the best yields. At high soil test K, 160 lb N/A resulted in best yields, which were considerably higher than those produced with 320 lb N/A, but with low soil K fertility. Similar relationships can be shown for other nutrient interactions as well. Synergism between and among essential plant nutrients can often boost yields much higher than when the nutrients are applied separately.

Data have shown that many farmers in the U.S. Corn Belt have been removing more P than they apply in the form of commercial fertilizers for several years. Indeed, recent state nutrient budgets often show negative balances for P and K...and even N. **Table 4** shows the 1982-1996 P nutrient budgets for Illinois. Data in **Table 4** indicate trends similar to those for other areas of the U.S. How long can farmers afford to mine their soils of P, K, and other nutrients and still grow high, profitable crop yields? The answer will vary, but for most it is, "not very long."

Table 5 shows the results of a long-term (10-year) study done in Maryland. It compares trends in N-only corn yields versus those where P and K were applied along with N. By the 10th year, the yield difference was 104 bu/A. Over the 10-year period, NPK corn averaged 152 bu/A compared to 73 bu/A for the N-only corn. How easy would it be for a farmer to lose 5, 10, 15, or more bushels per acre...without even knowing it...by cutting back on fertilizer use due to low commodity prices or because of some other economic challenge?

The primary goal of farmers as they evaluate changes in management systems is to increase profits. There are other goals as well.

- Environmental protection of soil and water resources;
- Compliance with state and federal regulations;
- Spending more quality time with family, including taking advantage of recreational opportunities;
- Leaving the farm in better shape...for the next generation...than the farmer found it.

The potential for profits, however, most often provides farmers the incentive to accept new technologies...to improve management. How are profits increased? Profits are the result of higher yields, improved market quality, better marketing skills, lower cost per unit of production...most likely, a combination of

TABLE 3. Nitrogen, P_2O_5, and K_2O consumption in the U.S., 1950-1998.

	Fertilizer consumption, 1,000 tons		
Year	N	P_2O_5	K_2O
1950	1,005	1,950	1,103
1955	1,960	2,284	1,875
1960	2,738	2,572	2,153
1965	4,639	3,512	2,835
1970	7,459	4,574	4,036
1975	8,601	4,507	4,453
1980	11,407	5,432	6,245
1985	11,504	4,641	5,510
1990	11,076	4,345	5,203
1995	11,720	4,417	5,123
1998	12,305	4,624	5,343

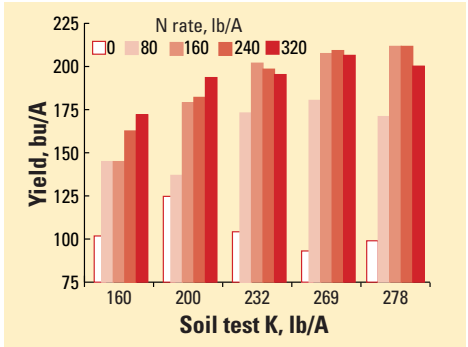

Figure 3. Adequate soil K level increases corn yield (Johnson & others, Ohio, 1992-95).

these factors.

There is a direct positive relationship between higher crop yields, if produced efficiently, and farmer profits. In a four-year Iowa Soybean Association survey, soybean growers were asked to keep track of several of their production costs, including tillage, planting, herbicides, nutrients, harvesting, land, and marketing. Growers were divided into groups, based on overall profitability. Production practices of the most profitable 20 percent were compared to those of the least profitable 20 percent.

Nearly 70 percent of increased income from the top 20 percent was attributable to higher yields (**Figure 4**). About one-fifth of increased income came from cost reductions, and less than 15 percent of the additional profits could be attributed to better marketing. We all appreciate the importance of cost control and marketing skills, but the primary driving force behind increased farmer profits is most often production of higher, more efficient crop yields.

In addition to the Iowa survey, recent studies in Kansas and Minnesota also ranked yield as a major characteristic of most profitable farmers.

While it is recognized that many factors characterize high yield farmers, one of the most critical of management inputs is the maintenance of soil fertility. The common perception is that soil fertility, specifically P and K soil test levels, seldom limit yields in North America. That perception is a myth.

PPI summarized the results of 1.8 million soil samples collected in the fall of 1996 and spring of 1997 and reported the percent of samples testing medium or below in P and K...along with pH levels of 6.0 or below. Of the 1.8 million samples included in the summary, 46 percent and 44 percent tested medium or below in P and K, respectively. The northern Great Plains had the highest frequency of medium or below P tests, in the 60 to 80 percent range, while a few states scattered around the U.S. fell in the 20 percent range. The summary also showed that significant numbers of soils have pHs too low for optimum crop production and efficient fertilizer use. (See *Better Crops with Plant Food*, 1998, No. 4, pages 16-18).

America's farmers face many challenges

TABLE 4. Illinois P budgets, 1982-1996.

	Removal		Inputs			Rem/
	Crop	Animal[1]	Fertilizer	Manure	Human	inputs,
Years	Short tons, thousands					%
82-86	517	8	466	112	16	88
87-91	498	8	385	106	16	100
92-96	574	8	381	101	16	117

[1]Meat, eggs, milk. R. Hoeft, University of Illinois

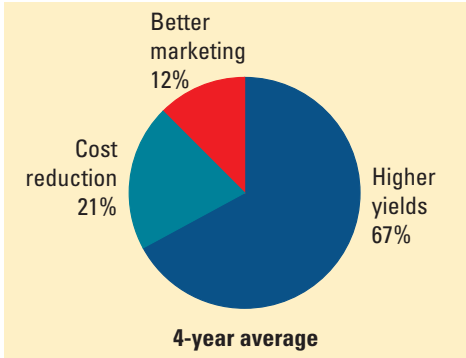

Figure 4. Characteristics of the most profitable farmers.

TABLE 5. Ten-year results of N-P_2O_5-K_2O vs. N fertilization of dryland corn.

N-P_2O_5-K_2O,	Yield, bu/A for year:									
lb/A/yr	1	2	3	4	5	6	7	8	9	10
160-160-160	151	149	159	153	134	159	122	190	182	125
160-0-0	146	139	116	80	104	37	13	52	23	21
Difference	5	10	43	73	30	122	109	138	159	104
Accumulated yield, bu/A										
160-160-160	151	300	459	612	746	905	1,027	1,217	1,399	1,524
160-0-0	146	285	401	481	585	622	635	687	710	731

Maryland

as they look to their future role in food production. They are truly a part of an international industry. They must be low-cost producers to remain competitive, and, at the same time, they must be profitable to stay in business. Profitable farmers will be better able to protect the environment, utilize resources, and produce abundant, safe foods. They will adapt to, adopt, and successfully use the contributions biotechnology will make.

The knowledge farmers use to make the progress necessary to feed tomorrow's world population...and feed them better than they are eating today...will come from new discoveries made from research. A part of that research will involve mineral nutrition and soil fertility. It will include studies on how to best manage soil variability and crop needs so that nutrients, both mineral and organic, can best be utilized.

Earlier, the question was asked, "What can be done to ease the effects of the current economic downturn?" Perhaps that is the wrong question. Rather, we should ask, "How can we make best use of emerging technology and combine it with proven science to continue to feed a growing world population?"

The obvious answer is to grow more yield per unit of land and do it at a higher profit by lowering unit production costs... while improving environmental protection. Building and maintaining high soil fertility...and providing balanced nutrition to the growing crop...will go a long way in making that scenario possible.

Dr. Darst is Executive Vice President, PPI, Norcross, Georgia (E-mail: bdarst@ppi-far.org). Dr. Fixen is Senior Vice President, PPI, Brookings, South Dakota (E-mail: pfixen@ppi-far.org).

High Crop Yields – Closing the Gap

This issue of *Better Crops with Plant Food* contains articles that describe circumstances surrounding record-breaking yields. These yields are summarized in **Table 1**. They clearly illustrate the remarkable attainable yields of today's genetic material and at the same time in striking fashion reveal the huge gap between attainable yields and the yields normally harvested. Narrowing that yield gap is the greatest:

- Profit opportunity available today to crop producers;
- Potential source of food for the additional 2.5 billion people expected on this planet by the middle of the next century;
- Source of environmental relief through enhanced carbon sequestration, increased nutrient use efficiency, and through freeing more land for buffer strips, wetlands, rain forests, and recreation.

TABLE 1. Record crop yields in North America reported in this issue.

Crop	Yield	Location	Year
Alfalfa	24.1 tons/A	Arizona	1982
Barley, spring	190 bu/A	Alberta	1990
Canola, spring	70 bu/A	Alberta	1999
Corn	394 bu/A	Iowa	1999
Cotton	5.4 bales/A	Arizona	1982
Soybean	118 bu/A	New Jersey	1983
Wheat, winter	205 bu/A	British Columbia	1988

So what does it take for an individual to exploit the yield gap? In one word, management...in a phrase, management and long-term dedication. The articles that follow summarize what has worked in some cases and hold insights into the necessary ingredients of a reproducible framework for high yields. However, much is yet to be learned about incorporating the power and efficiencies of today's technologies into a holistic, systems-level approach to crop, soil and water management. In other words, there are some exciting research opportunities waiting for us as we turn the corner to another century of agricultural progress.