Food for the Future–PPI's Role in Influencing Plant Nutrient Management

By David W. Dibb

Sustainability is one of the most compelling issues in agriculture. One of PPI's roles is to demonstrate that nutrient management, including the phosphorus (P) and potassium (K) supplied by commercially produced fertilizers, is a key component of sustainability.

SOME would define sustainability as simply maintaining production indefinitely at current levels. An even more restricted definition would be to accept and maintain some lower level of productivity indefinitely . . . since many simply equate sustainability with less inputs. PPI agrees with those who believe that true sustainability must include increasing production to meet the expanding food, fiber and fuel needs of a continually increasing global population.

The fact that a significant segment of the world population is currently not receiving an adequate diet must be a part of the sustainability equation. There are literally hundreds of millions of people . . . over 20 percent of the world's population by some estimates . . . who would upgrade their diets, above some "minimum level of adequacy," given the opportunity.

Population Growth

World population must be one of the major considerations in sustainability. Recent projections shown in **Table 1** indicate population will exceed 6 billion people by the year 2000 and 8.3 billion by the year 2025. Others estimate it will stabilize at 10 billion by 2100.

Table 1. World population and arable land trend estimates.

Year	Population, millions	Arable land, million hectares	Hectare/ person
1965	3,027	1,380	0.46
1980	4,450	1,500	0.34
1990	5,100	1,510	0.30
2000	6,200	1,540	0.25
2025	8,300	1,650	0.20

To put the population increase into a clearer perspective with regard to agricultural sustainability, over the next 10 years food will be required for nearly 100 million additional people per year, just to stay even. That is equivalent to adding about four Canadas each year. Perhaps even more striking is the thought that tomorrow morning there will be approximately 250,000 additional mouths to feed.

. . . in most developing countries . . . the greatest environmental degradation and human suffering clearly come from inadequate and imbalanced nutrient use and not from over-application.

One of the major problems related to this population increase is that about 90 percent of it will be in developing countries where there is already a deficit of food. Considerable debt in many of these countries precludes the purchase of needed food and presents a major problem in developing the resources necessary to improve agriculture.

Consumption Growth

Table 2 lists global food production in 1990 at about 4.6 billion gross tonnes. Over 90 percent of the human diet was direct plant products. If per capita food consumption were to remain constant, the 8.3 billion people in the year 2025 would require an additional 2.6 billion gross tonnes of food production, almost a 60 percent increase. But, over one billion people have marginal diets which, if improved to adequate levels, would

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Table 2. World food production, 1990.

	Million tonnes production			
	Gross tonnage	Edible matter[1]	Dry protein[1]	Increase, % 1980-90[2]
Cereals	1,970	1,640	165	20
Roots and tubers	575	154	10	5
Legumes, oilseeds, nuts	300	204	68	29
Sugarcane and sugar beet[3]	125	125	0	20
Vegetables and melons	450	53	5	26
Fruits	345	47	2	17
Animal products	850	168	74	24
All food	4,615	2,390	397	20

[1]At zero moisture content, excluding inedible hulls and shells
[2]1979-81 and 1989-91 averages used to calculate changes
[3]Sugar content only Source: 1990 FAO Production Yearbook

require a 100 percent increase in production to nine billion tons, or a steady increase of 2 to 2.5 percent per year.

Yield Increases: The Challenge

The United Nations Food and Agriculture Organization (FAO) estimates that only 24 percent of future food needs can come by putting new land into production. The remaining 76 percent will have to be produced by increasing crop yields on currently farmed lands.

Taking into account a modest increase in arable land, the area per person will decrease about one-third to 0.20 ha by the year 2025 (see **Table 1**). In China, the average is already down to 0.09 ha/person in 1993. This means that average yield per hectare will have to increase at least 65 percent to meet projected food needs at the nine billion gross tonnage level cited earlier. While this seems a daunting task, there are reasons to believe that such increases can be achieved.

Table 3. Highest U.S. average vs. reported world yields (tonnes/hectare) for selected crops.

Crop	Highest U.S. average (Year)[1]	Developing countries[2]	Reported world record[3]
Corn	8.4 (1994)	1.3	21.2
Soybeans	2.7 (1994)	1.3	7.9
Wheat	2.7 (1990)	1.6	14.5
Sorghum	4.1 (1992)	0.9	21.5
Potatoes	36.6 (1993)	9.1	94.2

[1]USDA data; [2]Wortman & Cummings; [3]PPI Survey

One reason is that average crop yields are well below the levels that have been reached in high yield trials around the world. This includes developed, as well as developing agriculture, as shown in **Table 3**. Another reason is that where technology has been applied, increases have exceeded the increases needed in the projection noted. Still another is that recent yield projections for the U.S., made by U.S. Department of Agriculture (USDA) economists for four key grain crops, are in line with yield increases that will be needed.

Yield Increases: The Process

Decades of agricultural research have provided the foundation for today's yields. Since agriculture is a dynamic system, continuous yield-enhancing research must be a high priority. Much of the technology applied to increase yields two or three times in China, the U.S., India, and other countries, was developed 10, 20 and 30 years ago.

A disturbing trend, however, is that investments in agricultural research are declining dramatically. Agronomy departments in the U.S. are being dissolved, international research centers are losing funding and the developed countries are cutting back on agricultural technology aid to developing countries (in PPI we struggle with budget because of industry changes at a time when PPI's role in encouraging practical production research is even more important). All of this decreased investment in research is occurring at a time that is critical to the development of the new scientific facts that will have to be the foundation of yield breakthroughs 20 or 30 years from now.

Even FAO, which is viewed as the advocate of food production in the world, is under considerable pressure to shift its emphasis from food production to environmental concerns. This is a sad situation

Table 4. Balanced fertilization increases crop yields in India.

Crop	Season, condition[1]	Number of trials	$N-P_2O_5-K_2O$ kg/ha	Percent yield response to: N	NP	NPK
Rice	K,U	380	120-60-40	49	74	99
Rice	K,I	9,634	120-60-60	27	51	56
Rice	R,I	5,686	120-60-60	28	51	53
Wheat	R,I	10,133	120-60-60	59	95	114
Corn	K,U	53	90-60-60	85	107	129
Chickpea	R,U	1,325	20-40-20	36	59	77

[1]K=Kharif, R=Rabi (seasons); I=irrigated; U=unirrigated

because in most developing countries, where FAO has its mandate, the greatest environmental degradation and human suffering clearly come from inadequate and imbalanced nutrient use and not from over-application.

Nutrients: Supply and Balance

One factor that is closely and directly correlated to yield increases and total production is nutrient supply. Nutrient source, whether organic or inorganic, is not a major question when it comes to supplying these needed nutrients. Both are simply the transfer of nutrients from one location to another–to a location which is more convenient (or available) for the growing crop to use. Availability of adequate nutrients is the question. Where available, both sources should be used together as increasing amounts of nutrients have to be supplied to increase production.

Both correct amounts and correct ratios of applied nutrients are critical to nutrient management and sustainability.

Nutrient mining is one of the key issues that influences current and future productivity . . . especially in Africa, Latin America and parts of Asia. Results from low input systems in the Peruvian Amazon, where newly slashed and burned tropical rain forest was initially productive, demonstrate how quickly they are mined of native nutrients and how within three years they are robbed of their productivity without adequate replacement.

While it is clear that increasing production relies on greater availability of nutrients, it is also important to understand that **nutrient balance** becomes the **key** to sustaining production. This is true for several reasons. First of all, each additional increment of yield becomes more difficult to achieve, thus greater management precision is required. Also, economics and environmental protection are important components of sustainability. Nutrient balance also affects these areas dramatically.

Both correct amounts and correct ratios of applied nutrients are critical to nutrient management and sustainability. Imbalance allows mining of the most deficient nutrients in the soil. Once the critical level is reached, yield falls dramatically . . . even though large aggregate amounts of nutrients might have been applied. Research trials over a number of years, summarized in **Table 4** for several crops throughout India, for example, have demonstrated the importance of balanced fertilization to increased crop yields.

Again, it is important to note that to assure sustainable production, nutrient balance must be supported by adequate nutrient supplies. The nutrient ratio applied in India may be closer to balanced than the ratio in China. However, amounts applied are so low that soil mining, degradation and food shortages in India are a

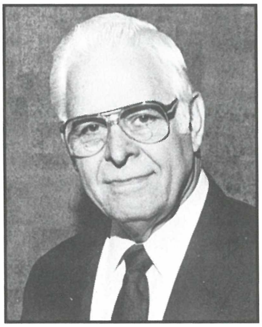
Table 5. Comparison of nutrient balance and application rates in India and China.

Country/Year	Nutrient ratio, $N:P_2O_5:K_2O$	Nutrients applied, kg/ha $N-P_2O_5-K_2O$	Cereal yield, tonnes/ha
India, 1991	5.9:2.4:1		
India, 1993	9.8:3:1	66.4	1.9
China, 1991	10:3:1		
China, 1993	8.4:2.6:1	*196	4.2

*150 if "unreported-unofficial" area is included

Robert E. Wagner Award Expanded by PPI

THE ROBERT E. WAGNER AWARD is being broadened in scope to better reflect the Institute's expanding international role. Established by the PPI Board of Directors in 1988, the Award recognizes distinguished contributions to advanced crop yields through maximum yield research (MYR) and maximum economic yield (MEY) management. The MEY concept, also known as most efficient yield, can provide a solid foundation for better meeting world food needs.



Dr. R.E. Wagner

The Award honors Dr. Wagner, retired President of PPI, for his many contributions to agriculture, to the fertilizer industry and to society in general. He is widely recognized for originating the MEY management concept . . . for more profitable, efficient agriculture.

In its new form, the Award will allow for worldwide candidate nominations and will have two categories . . . one for a senior scientist, one for a younger scientist under the age of 40. The recipient in each category will receive a $5,000 monetary award.

A committee of noted international authorities will select recipients of the Award on an annual basis. The Award will recognize outstanding achievements in research, extension or education. The focus will be on efficient management of plant nutrients and their positive interaction in fully integrated farm production systems. Such systems improve net returns, lower unit costs of production and maintain environmental quality.

The format for preparation of nominations for this Award can be obtained by contacting the Potash & Phosphate Institute, 655 Engineering Drive, Suite 110, Norcross, Georgia 30092-2821; phone (404)447-0335 ext 203, fax (404)448-0439. Private or public sector agronomists, crop scientists and soil scientists from all countries are eligible for nomination.

The first recipients for the Award will be selected in 1995. ■

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much greater problem than in China, and the average yields are also much lower, as shown in **Table 5**.

Whether in China, in India, in Canada or in the U.S., wherever increased yields are a necessity, the only way that balanced fertilization and sustainable high yields will be achieved is through the increased supply of commercial fertilizer nutrients.

Nutrient Balance: Beyond NPK

Nutrient balance discussions are often confined to nitrogen (N), P and K because of their major importance in crop production. Also, they are most often the limiting factors that need to be addressed in solving nutrient deficiencies. Balance, however, goes beyond NPK. For instance, in a survey of soils throughout China, 22 percent were deficient in sulfur (S) and 13 percent deficient in magnesium (Mg).

Clearly, nutrient balance goes beyond NPK and will not be achieved without adequate availability of commercial fertilizer nutrients.

Summary

In order to meet all objectives of sustainable agriculture . . . increased food, feed and fiber, profitability, efficiency of input use and an appropriate concern for the environment . . . a balance of adequate levels of nutrients is the key component. It is critical that nutrient balance, including the ready availability of needed commercial fertilizer nutrients, be an objective rather than a casualty of policy decisions.

PPI's role is to ensure that plant nutrient P and K are recognized as a part of and not apart from sustainability and that they are managed in balance with other nutrients and production inputs. ■