The Role of Plant Nutrition in Narrowing Yield Gaps in Global Wheat Production

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Introduction

- By 2030, global cereal demand for food and animal feed is expected to be 2.8 billion t/yr; 50% higher than in 2000
- Wheat is a staple in almost all human diets; however; grain yields around the world typically range between 20 and 80% of yield potential.
- Common factors contributing to yield gaps include water stress and flooding, soil problems, pest pressure, and nutrient deficiencies and imbalances.
- Increasing wheat grain yield to meet the growing demand will require significant reductions in current yield gaps.
- Defining the roles specific factors play in creating yield gaps will help identify the crop management practices necessary to narrow the gap between the potential yield and the actual yields obtained by growers.

Objectives

(1) Estimate current wheat grain yield gaps using actual grain yields being obtained in farmer fields and under optimal (non-limiting) fertility conditions

(2) Determine the contribution of plant nutrition to current yield gaps

Materials and Methods

- ***Selected Locations*** Ten major wheat producing countries have been selected for this project: Argentina, Australia, Canada, China, France, Germany, India, Kazakhstan, Russia, and the United States. Each country is divided into regions characterized by factors affecting yield potential (i.e. wheat type grown, climate, soil type, etc.). Within each region, 10-20 locations are identified for data collection (usually counties or agricultural districts).
- ***Data Collected*** Average wheat grain yield data were obtained from government statistics, agricultural market consultants, and published literature. Non-limited yields (wheat grown under optimum fertility conditions) were obtained from university and industry fertilizer response studies.
- ***Calculation Methods*** Yield gap for this study is defined as the difference between the yield obtained under optimum fertility (limited only by environment) and the yield obtained in farmer fields.
- ***Reported Data*** Data collection has only been completed in three countries, China, Russia, and the United States. For reporting, one representative region was selected from each country (Figure 1). Information about each region is reported in Table 1.

Figure 1. Wheat producing regions where data collection is completed.

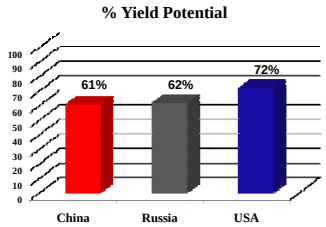

Figure 2. Percentage of yield potential (non-limiting fertility) currently being obtained in grower fields.

Country	Region	Locations	Wheat Type
China	North Central	20 counties within Hebei and Shanxi provinces	Irrigated, HRWW
Russia	N. Caucasus & S. Russia Steppe	20 districts within Rostov Oblast, Stavropol Krai, and Krasnodar Krai agricultural administrative regions	Rainfed, HRWW
United States	Central Great Plains	20 agricultural districts within the states of Kansas, Oklahoma, Texas, and Colorado	Rainfed, HRWW

Table 1. General description of wheat regions.

Results

- Yield data from 2004 through 2008 from the three regions are reported in Table 2.
- Wheat grain yields in the three regions were fairly consistent from year to year, averaging 2.0, 3.7, and 5.2 Mg/ha in the US, Russia, and China, respectively.
- These average yields represented grain yield gaps of 0.8, 2.3, and 3.4 Mg/ha for the US, Russia, and China, respectively.

Region	2004	2005	2006	2007	2008	Average
North Central China	Mg/ha					
Average Yield	5.2	5.0	5.4	5.4		5.2
Non-Limited Yield	8.3	8.5	8.7	9.0		8.6
Yield Gap	3.1	3.5	3.3	3.6		3.4
Southern Russia						
Average Yield	3.7	3.8	3.5	3.3	4.2	3.7
Non-Limited Yield	6.3	6.1	5.7	5.4	6.5	6.0
Yield Gap	2.6	2.3	2.2	2.2	2.2	2.3
U.S. Central Great Plains						
Average Yield	2.0	2.1	1.5	2.1	2.1	2.0
Non-Limited Yield	2.7	2.4	2.3	2.6	3.7	2.8
Yield Gap	0.7	0.3	0.8	0.5	1.6	0.8

Table 2. Wheat grain yields from farmer fields and non-limiting fertility experimental studies and associated yield gaps.

Results

- Grain yield gaps expressed as the percentage of yield potential currently being obtained in grower fields are illustrated in Figure 2.
- The yield gaps estimated in this study are comparable to those reported in literature for similar regions (e.g. India, 63%; Yaqui Valley, Mexico, 71%, Lobell et al., 2009)

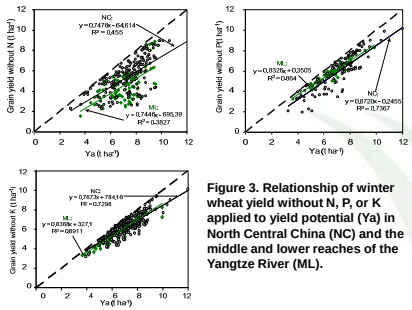

Figure 3. Relationship of winter wheat yield without N, P, or K applied to yield potential (Ya) in North Central China (NC) and the middle and lower reaches of the Yangtze River (ML).

Results

- In a separate study, the relationship between grain yield potential and yield obtained in N, P, and K omission plots for two regions in China, 2000-2008, were determined (Figure 3).
- Average grower yields obtained in these regions during 2000-2008 were 6.3 and 5.8 t/ha in NC and ML, respectively.
- Average yield potentials for NC and ML were 7.1 and 6.5 t/ha, respectively.
- These data indicate that N is the most limiting nutrient in both regions; P appears to be contributing to the yield gap in NC China, while K-limited yields seem to be more prevalent in the ML region of China.

Future Work

- Data collection and analysis will continue for other countries.
- An additional yield potential estimate for each region will be generated using the CERES-wheat growth model.
- Investigation to determine nutrient factors contributing to wheat grain yield gaps will continue using omission plot data and assessments of current nutrient management practices.

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