Improvement of Soil Nutrient Management via Information Technology

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Site-specific nutrient management (SSNM) can increase incomes in small, family field plot-scale systems through the identification of soil variability and implementation of rational nutrient application.

Precision agriculture plays an important role in crop production and environmental protection. However, in Shanxi Province, where each farm family is assigned to operate one, or several, small field plots with an average size of 0.1 to 0.2 ha, farmers' fertilizer decision-making processes are commonly limited due to little understanding of soil nutrient status or spatial variability of their small field plots. It is also difficult to study the spatial variability of soil nutrients and develop the variable rate techniques under such circumstances in developing countries (Jin, 1998). This study was conducted in the monitored village of Ershilipu, in Xinzhou City, to develop an approach to meet the needs of SSNM for these farming systems.

At the SSNM study site with maize at vegetative stage, Mr. Bin Wang compares growth with farmers' practice (at left) and recommended fertilization (right).

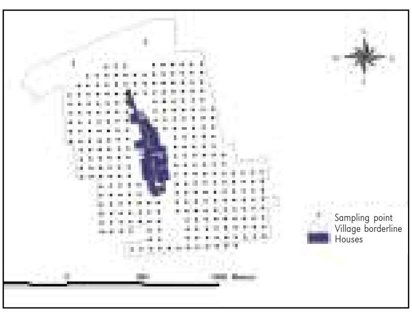

Figure 1. Distribution of sampling points at experiment site.

Maize is a major crop in Shanxi, with planted area of 915,450 ha and an average yield of 5.21 t/ha. The local climate at the experiment site is semi-arid monsoon, with an average annual rainfall of 405 mm, an average temperature of 8.5 °C, and a frost-free period of about 160 days. The soil type is a poorly drained alluvial classified as Fluvo-aquic.

A total of 280 soil samples from 0 to 20 cm depth were collected using a 100×100 m grid during March 2000 (**Figure 1**). Soil nutrients were determined according to procedures applied by the National Laboratory of Soil Testing and Fertilizer Recommendation... formerly called the Chinese Academy of Agricultural Sciences (CAAS)-PPIC Cooperative Soil and Plant Analysis Laboratory. Farmers' field plot distribution was mapped with a TOPCON geodesic apparatus (**Figure 2**) and soil nutrient maps were developed by ArcView Geographic Information System (GIS) 3.2. Ten field plots were selected with a differential global positioning system (DGPS) to monitor the effect of SSNM and guide soil fertility management and fertilization.

Results in **Table 1** show that soil properties of the site varied greatly. Coefficients of variation (CV) were greatest for available ammonium-nitrogen (NH_4^+-N), phosphorus (P), and organic matter (OM) at 68%, 46%, and 48%, respectively. Many researchers have pointed out that soil parent materials, vegetation, till-

Table 1. Statistical feature of selected soil properties at experiment site.

	pH	OM, %	K, mg/L	NH_4^+-N, mg/L	P, mg/L
Maximum	8.2	0.83	136.9	30.4	42.3
Minimum	7.7	0.03	46.9	0.1	1.1
Mean	8.0	0.22	88.3	8.3	8.3
Standard deviation	0.1	0.10	16.6	5.7	3.8
CV, %	1.2	47.5	18.8	67.9	46.0
Critical value			78	50	12
Percentage[1]			22.9	100	86.4

[1]The ratio between number of samples below critical value and the total sampling number.

age, fertilization, cropping history, and other factors, can influence the variability of the physical and chemical properties of fields (Carr et al., 1991; Bouma and Finke, 1993). A survey of farmers' fertilizer use for the maize cropping system in 2003 indicated that N and P were widely applied with the average being 200 kg N/ha (CV of 43%) and 121 kg P_2O_5/ha (CV of 70%), respectively. Potassium (K) and micronutrients were commonly ignored in this system. Large differences in fertilization practice are likely a major cause of soil variability. In turn, the smaller spatial variability for soil K (CV of 19%) may be related to little K input within the region. The average soil test levels for NH_4^+-N, P, and K were 8.3 mg/L, 8.3 mg/L, and 88.3 mg/L, respectively. The percentage of samples below critical values were 100% for NH_4^+-N, 86% for P, and 23% for K.

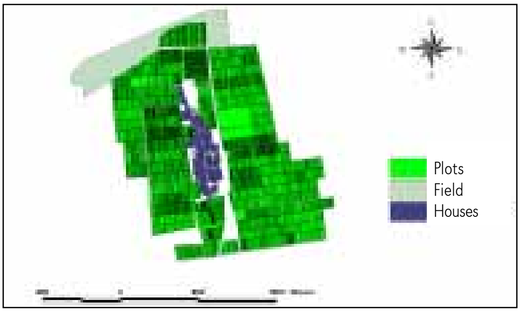

Figure 2. Distribution of farmer plots at experiment site.

Contoured soil property maps may directly reflect the spatial distribution characteristics of soil nutrient elements (**Figures 3** and **4**). Maps of soil nutrient status for each small field plot were obtained on GIS by overlaying the contour map of soil nutrients with a distribution map of farmers' fields. Phosphorus was deficient in most of the site, excluding a small area adjacent to greenhouses that had available P above 13 mg/L. This is closely related to higher input of organic manure and P fertilizers on vegetable crops grown under greenhouses. Soils deficient in P (7 to 13 mg/L) were normally found in the western region of the village where maize is largely grown with insufficient supply of P fertilizer. The most severe P deficiency (less than 7 mg/L) occurred along top and bottom edges on the east side of the village due to little fertilizer input and sandy soil texture. Soil K fertility followed a simi-

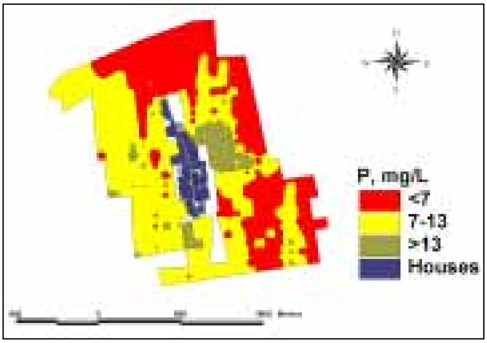

Figure 3. Distribution of soil P at experiment site.

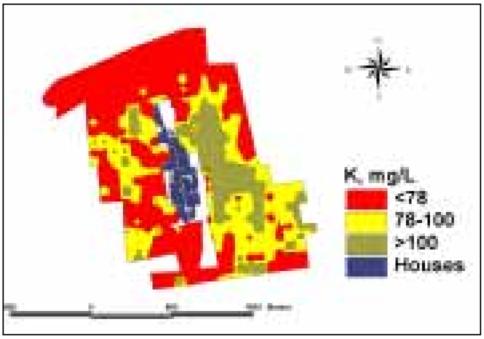

Figure 4. Distribution of soil K at experiment site.

Table 2. Responses of maize yield and net income to SSNM.

Field No.	Yield, kg/ha Farmers' practice	SSNM practice	Increase, %	Net income, US$/ha Farmers' practice	SSNM practice	Increase, %
1	7,470	8,250	10.4	983	1,052	7
2	6,975	7,815	12.0	909	978	8
3	9,015	9,495	5.3	1,215	1,230	1.2
4	9,465	10,590	11.9	1,283	1,401	9
5	7,170	7,935	10.7	938	1,005	7
6	8,100	10,125	25.0	1,078	1,324	23
7	9,045	10,815	19.6	1,220	1,437	18
8	10,575	11,175	5.7	1,449	1,482	2.3
9	8,190	9,165	11.9	1,091	1,180	8
10	7,545	8,430	11.7	995	1,070	8
Average	8,355	9,380	12.4	1,116	1,216	9

lar trend, thus P and K spatial distribution are both closely related to fertilization history and soil texture (**Figure 4**).

Farmers are inherently interested in these maps due to the visual description of soil nutrient status of their fields. Maps are used by villagers to guide their fertilization. Fertilizer recommendations are provided for each plot and farmer using Systematic Approach technology, which was developed by Dr. Arvel Hunter, Agro Services International Inc., and introduced to China in 1988. Variable SSNM fertilization is subsequently applied by hand. Field growth under SSNM was more vigorous compared to common farmer practice (see photos). Final results also showed that recommended SSNM fertilization significantly increased maize yield and net income compared to common practice (**Table 2**). Maize yield increased by 5 to 25% with an average yield increase of 1,025 kg/ha, or 12%; net income improved by 1 to 23% with the average increase being US$100/ha, or 9%.

At jointing stage, difference in growth with the check (farmers' practice) and recommended fertilization (right) are apparent.

Summing up, large spatial variability existed for soil properties measured in this monitored village. Greater variability occurred for soil NH_4^+-N, P, and OM, while soil K had smaller spatial variability–a reflection of the relative intensity and history of fertilizer use. These results support the use of SSNM to help farmers produce higher yield and income with rational fertilization. BC

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