Spatial Variability in Available Nutrient Status in an Intensively Cultivated Village

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Available nutrient status showed wide variation across the study area which was associated with fertilization history and the cropping sequence adopted by individual farmers.

Fertilizer management is a major consideration in agricultural production. Inadequate fertilizer application limits crop yield, results in nutrient mining, and causes depletion of soil fertility. An excessive or imbalanced application not only wastes a limited resource, but also pollutes the environment. So farmers are faced with an ever-increasing demand for finely tuned fertilizer management – with economic optimization on one hand and environmental concerns on the other. An approach towards mitigating such concerns is site-specific nutrient management (SSNM)...as opposed to a blanket fertilizer recommendation followed over an extended area irrespective of soil and crop concerned...which takes into account spatial variations in nutrient status cutting down the possibility of over or under use of fertilizer. The current study evaluates the extent of spatial variations in available nutrient status at Sripurdanga Village of Murshidabad District in the alluvial soil zone of West Bengal, India, to highlight the need of factoring in such variations in fertilizer management.

The soil in the study area is a fine loamy Typic Ustifluvent. Rice is the major crop in this area, grown twice a year during February to May and July to October. A variety of other crops, including vegetables, pulses, oilseeds, jute, and flowers make up the cropping sequences. Average farm size is 1 ha or less and fertilizer applications are limited to farmers' perception, or at best, based on general recommendations provided for the whole state. Average rainfall is 1,340 mm and average temperature varies between 8 to 40 ºC.

A total of 32 soil samples were collected from 0 to 15 cm depth at a 100 x 100 m grid during April 2006. GPS coordinates of the sampling points were recorded using a GARMIN Map 60 instrument. Soil physiochemical properties and available nutrient status were measured by standard procedures (Page et al., 1982). Descriptive statistics of the measured soil properties showed wide variations (**Table 1**). Except for pH, all the other parameters had CV values greater than 24%, the highest being 90% in the case of Fe.

A survey of the cropping systems and fertilization history for the study area was performed to relate nutrient variability with existing farming practices. High spatial variability in soil P content was found to be a result of differences in P application rates between vegetable farmers and rice farmers. Variability in soil S content could be related to S application by some farmers, through single superphosphate, and a lack of such application by other individuals. Potassium has lower spatial variability compared to P and S, most likely due to generally low application rates (Wang et al., 2006). Thus, the main source of variability for soil K was related to type of crop cultivated rather than application rates. The high variability for all micronutrients, except Cu, was quite surprising and needs further study for a proper explanation (**Table 1**).

Various studies have shown that spatial variability of soil properties, including nutrient status, can occur across fields owing to tillage, fertilization, cropping history, and other reasons. A study on soil fertility variability within a 50 ha cotton field in Handan County of Hebei Province, China, showed remarkable variability in available soil nutrient content with available P, K, and B having CVs greater than 30% after 20 years of small-scale operations. A similar study on a 20 ha field within a large-scale, single operational unit (Changyang State Farm) in the suburb of Beijing showed a lower extent of spatial variability compared to small-scale operations (Jin, 2005). Under the small-scale operations, where each farming family operated small plots, the variability of soil nutrients had a close relation with history of fertilization, crop variety, and field management.

Spatial variability maps of the soil nutrient status, soil pH, and organic C were created for the study area using GIS (ESRI, 2001) by overlaying the soil nutrient contour maps over the sample point distribution map (**Figure 1**). The P distribution map shows high available P in most parts of the study area except for some isolated patches of medium P fertility. This was most likely due to high P input in all crops in this area, mostly through diammonium phosphate (DAP) application. Higher available soil P content was found in part of the study area where vegetables are grown with much higher P inputs compared to other crops.

However, K fertility status was found to be rather low in the study area. Except for some isolated patches of high K content, most of the soils have very low to medium fertility. As with P, a distinct region of the southern part of the study area had higher

Table 1. Descriptive statistics of the measured soil properties at the experimental site.

Property	Minimum	Maximum	Mean	Standard deviation	CV, %
pH	6.8	7.9	7.4	0.3	4
EC, ds/m	0.1	0.7	0.4	0.2	58
Organic C, %	0.2	1.1	0.7	0.2	25
Total N, %	0.02	0.09	0.06	0.01	24
P_2O_5, kg/ha	50.4	366.4	194.0	98.7	51
K_2O, kg/ha	87.0	448.0	254.2	93.0	37
S, ppm	7.8	82.5	19.5	12.8	66
Zn, ppm	0.2	3.8	0.9	0.7	73
B, ppm	0.4	5.0	2.0	1.2	57
Fe, ppm	1.8	40.	7.8	7.0	90
Cu, ppm	1.1	3.5	2.0	0.5	24
Mn, ppm	2.6	35.8	12.0	8.9	74

Abbreviations and notes for this article: GPS = global positioning system; GIS = geographic information systems; CV = coefficient of variation; N = nitrogen; P = phosphorus; K = potassium, Fe = iron; S = sulfur; Mn = manganese; B = boron; Zn = zinc; C = carbon; ppm = parts per million.

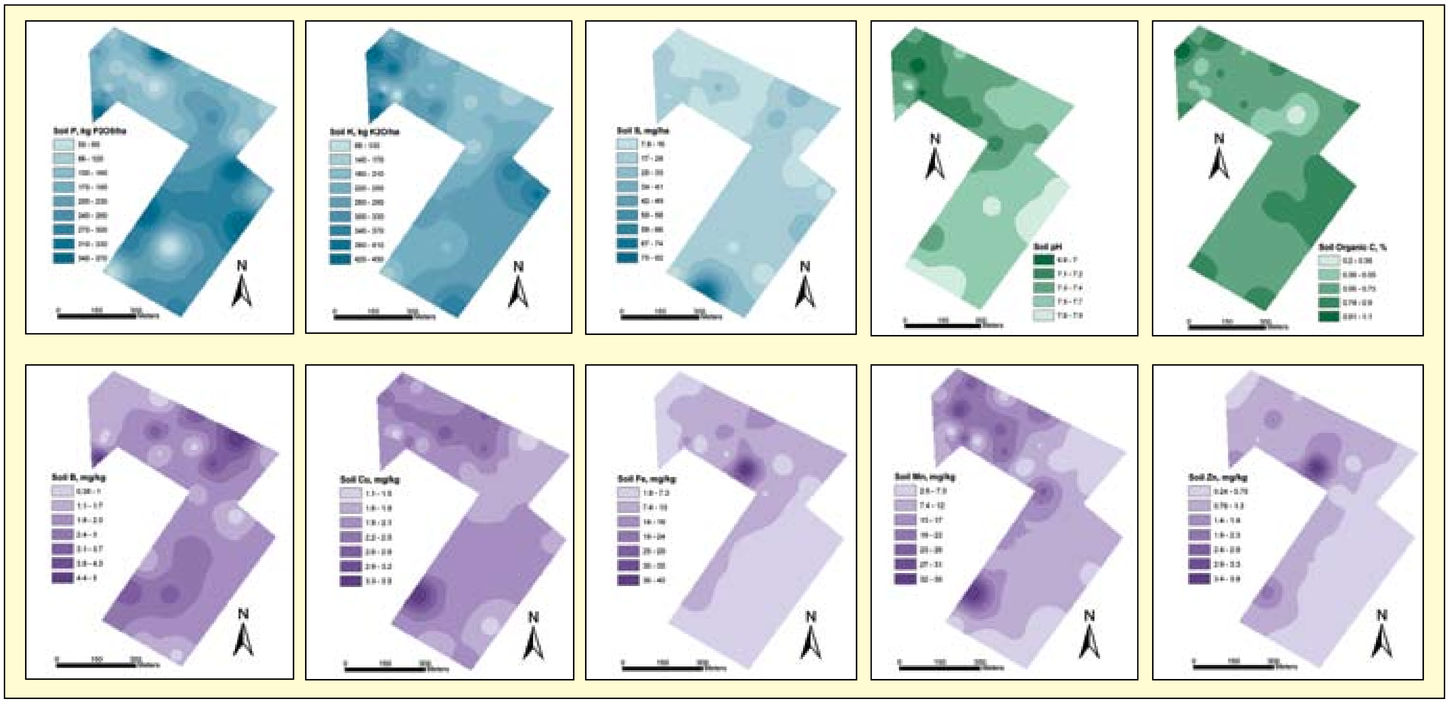

Figure 1. Distribution of available P, K, S, B, Cu, Fe, Mn, Zn, soil pH, and organic carbon at the experimental site near Sripurdanga Village, West Bengal, India.

K content compared to other areas. Our survey revealed that farmers grow vegetables in this area and consequently apply more nutrients than in cereals.

The average application rate for K fertilizers is much less than N and P fertilizers. Low use of K fertilizers and high leaching loss of K due to frequent irrigation are the most likely reasons for widespread K deficiency in the village, irrespective of cropping systems followed.

The survey revealed that multi-nutrient deficiencies have developed in fields where farmers opted to follow a particular cropping system for several years. Deficiencies of K, Zn, and Fe have developed in fields where jute/paddy/wheat or jute/paddy/paddy sequences were followed for the last 7 to 10 years. The sandy loam to loam texture of the soil and prevailing soil pH above 7.0 are main contributing factors to this region's Zn and Fe deficiencies. Besides, lack of organic matter application coupled with no application of Zn in a rice-based system will aggravate soil Zn deficiency.

In general, the study area was found to be deficient in available S. Sulfur deficiency was particularly widespread in fields where one or two oilseed crops are included in the cropping sequence. More often than not, farmers use high analysis fertilizers with little or no S and irrigate their fields frequently. In absence of adequate S, cultivation of one or two oilseed crops…or vegetables of the cruciferous family such as cabbage and cauliflower…can cause acute S deficiency in the soil. The survey and soil analysis reports also showed that S deficiency of soils can be avoided with application of S fertilizer at least once in a cropping sequence.

Spatial variability for micronutrients can be partially explained with in-situ knowledge of the study area's production systems. Relatively high concentrations of Cu can be related to the frequent use of pesticides containing Cu. The maps for Zn and Fe show deficient areas in the southeast and northwest. Both of these areas have extended rice/vegetable sequences and the resulting nutrient removal would be high. Rice demand for Zn and Fe is high and removal would be further accelerated under the higher nutrient input situation of growing vegetables.

The northwestern part of the study area also represents a significant area of B deficiency. The northwest represents a transition zone between the uplands and lowlands and continuously higher soil moisture contents would contribute to higher leaching of B from this area.

The current study revealed major variability in soil nutrient status within a small area of an intensively cultivated village. The cropping pattern and fertilization history of individual plots seemed to be the cause of such variability.

The fertilization plan of an individual farmer should take into account this variability to optimize nutrient application rates for better yield and economics of crop production. Experiments are now being designed to develop SSNM strategies for the area based on spatial nutrient variability maps. BC

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