Evidence-based nutrient management strategy in identifying fertility status and soil constraints for vegetable production in the Southern Philippines

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Abstract
Participatory and soil assessment surveys were conducted in five major vegetable producing areas in Southern Philippines to define the current nutrient status and management practices involving vegetable production. Five sites were identified in each area representing four regions in Southern Philippines that were identified as vegetable producing farms and represent the major sources of vegetables sold in the Visayas and Mindanao islands. Soil samples were gathered in each site representing the 0-20 cm and 20-40 cm depth and were analyzed in the laboratory for its physico-chemical characteristics. In the participatory assessment surveys, more than 100 farmers were interviewed for the current management practices they employed in vegetable production and the major problems they encountered in producing vegetables. The key outcomes of these investigations are: 1) growers identified lack of capital and high fertilizer prices as a key constraint to vegetable production; 2) the results of soil fertility evaluation suggests that growers are undersupplying some nutrients and oversupplying others leading to nutrients imbalances in the soil and, 3) lack of capital is not an issue but an issue of more effective allocation of limited capital (fertilizer) resources.

Key Words
Participatory assessment, soil survey, vegetable production, constraints, Southern Philippines.

Introduction

Improving soil quality for better crop production has long been a primary objective of soil science, but many problems of soil quality remain. Sustainable soil nutrient-enhancing strategies involve the wise use and management of inorganic and organic nutrient sources in ecologically sound production systems (Janssen, 1993). The primary goal of integrated nutrient management (INM) is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicious and efficient way. Integrated nutrient management optimizes all aspects of nutrient cycling. It attempts to achieve tight nutrient cycling with synchrony between nutrient demand by the crop and nutrient release in the soil, while minimizing losses through leaching, runoff, volatilization and immobilization (Jou and Hossner 1998).

Providing higher economic returns per unit area and developing new export markets for high value crops in the Philippines has been identified as a priority by the Philippine Government and the Australian Centre for International Agricultural Research (ACIAR) as means of increasing economic growth and improving the standard of living of people living in rural areas. Regions VIII (Leyte), X (Northern Mindanao/Cagayan de Oro) and XI (Southern Mindanao/ Davao) have significant potential for expanding vegetable production. Moreover, they are seen as strategically important to the Australian Government, whereby efforts to improve the livelihoods of the populations in these areas could contribute to improving geo-political stability in the region.

A number of barriers exist to achieving these objectives including: lack of grower expertise in soil management and crop agronomy; high incidence of pests and diseases; lack of developed markets and value chains for horticultural produce; and political/economic constraints, such as limited capital/resources and insecurity of land tenure. To address these issues, a research was conducted to define current soil fertility status and management practices in vegetable producing areas in the Southern Philippines through participatory assessment and soil survey and, to develop more productive nutrient management systems for vegetables based on the results of soil analyses for each of the area surveyed.

Methods

Soil sampling and preparation

Soil samples were obtained from five study sites representing three regions of Southern Philippines known to produce vegetables (Region 8 - Cabintan, Ormoc City; Region 10 - Claveria, Misamis Oriental and Maypayag, Malaybalay, Bukidnon; and Region 11 - Kapatagan, Davao del Sur) (Figure 1). These sample composites were made up of ten soil core subsamples that were collected from 0-20 cm using the Australian standard core sampler in each study sites. The soil samples were immediately air-dried, pulverized using a wooden mallet, and sieved in 2 mm wire (#10 sieve). Samples for organic matter and nitrogen analysis were sieved using the 0.425 mm wire mesh (# 40 sieve). Particle size distribution was analyzed using the pipette method after pretreatment of soil samples with H_2O_2 to remove organic matter (OM) (ISRIC 1995).

Soil chemical properties

Soil pH was determined using the potentiometric method at a soil-water ratio of 1:2.5 (ISRIC 1995). Total Nitrogen (%) was analyzed following the procedures of Keeney and Nelson (1982). Organic matter was analyzed using the modified Walkley-Black method (Jackson, 1958). Available Phosphorus (mg/kg) was determined according to the Olsen and Bray No. 2 methods for calcareous and acidic soils, respectively (PCARR, 1980). Exchangeable K, Ca, Mg, Na (mg/kg) were extracted using 1 N NH_4OA_c adjusted to pH 7.0. Determination of bases was done by atomic absorption spectrophotometry (AAS). Exchangeable acidity and aluminum were analyzed by extracting the exchangeable acidity (H + Al) in the soil by unbuffered KCl solution and quantified by titration method (ISRIC, 1995). Cation exchange capacity (CEC) was determined using 1 N NH_4OAc at pH 7 as the extracting solution (USDA-NRCS, 1996).

In determining the critical levels of nutrients for vegetables based on the results of soil analysis, the criteria presented in Table 1 was used for soil pH and important soil nutrients such as N, P and K (AVRDC, 1990).

Table 1. Critical levels of nutrients for vegetables.

Parameters	Low	Moderate	High
Soil pH, water	5.5-6.0	6.0 -7.5	> 7.0
OC, %	2.0	4.0	>5.0
Total N	<0.2	0.2-0.3	>0.5
Bray No. 2 P (mg/kg)	<10	10-20	20-30
Exch. K (mg/kg)	40-80	80-120	120-160

Soil fertility constraints

Soil fertility constraints were identified by: interviewing farmers regarding current fertilizer and nutrient management practices; undertaking a baseline survey of soil fertility in key vegetable producing districts and on representative soil types of Mindanao and Leyte. The alternative nutrient inputs such as abundance, nutrient supply, cost, effect on soil physical, chemical and biological properties were also noted.

Results

The major key outcomes of Participatory Assessment include the growers identified lack of capital and high fertilizer prices as a key constraint to production and the low fertility status of the soil. However, the results of soil fertility evaluation and current fertilizer and nutrient management practices (Tables 2 to 4) suggests that growers are undersupplying some nutrients and oversupplying others leading to nutrient imbalances in the soils. Consequently, it is not an issue of lack of capital as identified by the farmers but an issue of more effective allocation of limited capital (fertilizer) resources.

Table 2 presents the average values of nutrients determined in the five sample farms for each site. These values were used as basis in establishing the critical levels of nutrients for each site as presented in Table 3. For percent organic carbon, both the Cabintan and Claveria sites indicated high values, while the Malaybalay, Lantapan and Kapatagan sites have low values. For total N, both the Cabintan and Malaybalay sites have high values, followed by the Lantapan and Kapatagan sites which have moderate values and the Claveria site has the lowest value. For available P measured using Bray P no. 2, three sites (Cabintan, Lantapan and Kapatagan) have low values, followed by Malaybalay site which has moderate value and the Claveria site has high value. For exchangeable K, the 5 sites have high values.

Table 2. Average values of soil chemical properties of the five sites surveyed for each major vegetable producing area in the southern Philippines.

Sites	Soil Depth (cm)	Soil pH H_2O	OC (%)	Total N (%)	Bray P (mg/kg)	Exch. cations (me/ 100g soil)					Exch. Acidity	CEC
						K	Na	Ca	Mg	Al	(me/ 100g soil)	
Cabintan	0-20	5.39	5.54	0.45	0.14	0.42	0.11	0.80	0.14	0.56	0.77	1.89
Claveria	0-20	5.97	5.51	0.17	22.29	0.63	0.08	5.94	0.52	0.20	0.36	7.63
Malaybalay	0-20	5.69	3.57	0.29	0.29	0.34	0.13	0.14	2.03	0.29	0.38	2.99
Lantapan	0-20	5.72	3.72	0.46	11.22	1.56	0.12	1.93	6.15	0.36	0.49	9.09
Kapatagan	0-20	5.66	1.99	0.23	0.83	1.64	0.21	4.54	0.92	0.22	0.37	7.73

Table 3. Critical levels of nutrients present in each site based on the results of soil analysis.

Parameter	Cabintan	Claveria	Malaybalay	Lanpatan	Kapatagan
pH (H_2O)	Low	low	Low	Low	Low
OC (%)	High	High	Low	Low	Low
Total N (%)	High	low	High	Moderate	Moderate
Avail P (mg/kg)	Low	High	Moderate	Low	Low
CEC (meq/ 100g soil)	Low	Low	Low	Low	Low
Exch K (mg/kg)	Mod-high	High	High	High	High

In the preliminary mass nutrient balances established for the four vegetable production systems, results suggests that nutrients such as N, P, K were oversupplied in Claveria site while other nutrients such as K were undersupplied in Kapatagan site (Table 4). Among the four sites, the Claveria site has the highest surplus of nutrients based on the current management practice of the farmers, while the Kapatagan site has the lowest surplus of nutrients.

From the results of the participatory assessment and soil survey, a research program which has strong focus on the establishment of a fertilizer strategies based on supplying the most cost effective method of supplying the nutrient requirement, was developed for each site and are currently evaluated in the field.

Table 4. Mass balances of nutrients for specific vegetable planted based on the current management practices in each site.

Crops	Site	Nutrients Applied (kg/ha)			Nutrients removed (kg/ha)			Deficit/surplus (kg/ha)		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Tomatoes	Claveria	209	201	314	55	15	75	154	186	239
	Cabintan	24	19	28	11-22	3-6	15-30	7.5	14.5	5.5
Potatoes	Lantapan/Mal	91	90	89	11	10	24	80	80	65
	Kapatagan	65	52	23	25	6.4	41	40	45.6	-18
Brassicas	Cabintan	145	32	32	13	5	16	132	27	16
	Lantapan/Mal	24	19	21	14	5	17	10	14	4
	Kapatagan	24	28	19	58	21	69	-34	7	-50
Total	Claveria							154	186	239
	Cabintan							139.5	41.5	21.5
	Lantapan/Mal							112	120	78
	Kapatagan							6	52.6	-68

Conclusion

This study implied a strong need for soil survey in assessing the fertility status of fertility status of soil and in the establishment of mass balances of nutrients that has been supplied in the soil through fertilization and removed from the soil by crop uptake. This will guide farmers and researchers in planning an effective management strategy for a more profitable vegetable production. From these findings, a research program which has strong focus on the establishment of fertilizer strategies based on supplying the most cost effective method of providing the nutrient requirements, was developed for each site and are currently established and evaluated in the five sites.

References

AVRDC (1990) Vegetable production training manual. Asian Vegetable Research and Development Center. Shanhua, Tainan. 447 p. Reprinted 1992.

International Soil Reference and Information Center (ISRIC) (1995) Procedures for Soil Analysis (Ed. LP Van Reeuwijk) Wageningen, The Netherlands. 106 pp.

Jackson ML (1958) Soil Chemical Analysis. Amer. Soc. of Agron., Inc. Englewood Cliffs, USA. 498 pp.

Janssen BH (1993) Integrated nutrient management: the use of organic and mineral fertilizers. *In* The Role of Plant Nutrients for Sustainable Crop Production in Sub-Saharan Africa (Eds. H van Reuler and WH Prins), pp.89-105. (Ponsen and Looijen: Wageningen, The Netherlands).

Juo SR, Hossner LR (1998) Soil Nutrient Management for Sustained Food Crop Production in Upland Farming Systems in the Tropics. Soil and Crop Sciences Department College Station, Tennessee, 77843, USA.

Keeney DR, Nelson DW (1982) Nitrogen-inorganic forms. *In* Methods of Soil Analysis: Part 2. Agronomy Monograph No. 9. 2nd edition'. (Ed,. AL Page *et al*.), pp 643-687.(ASA and SSSA: Madison, WI).

PCARR (1980) Standard Methods of Analysis for Soil, Plant Tisssue, Water and Fertilizers. Farm Resource and System Research Division. Los Baños, Laguna. 190 pp.

Yoo Sun-Ho, Jung Yeong-Sang (1991) Soil Management for Sustainable Agriculture in Korea. College of Agriculture and Life Science, Seoul National University, Suwon, Korea.