Integrated nutrient management for increased cabbage production in volcanic soil in Cabintan, Leyte, Philippines

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Abstract
One of the major issues affecting vegetable production in the Southern Philippines is the improper allocation of limited resources such as fertilizers due to lack of knowledge of the nutrient status of the soil. A study was conducted in Cabintan, Ormoc City, Philippines to: i) study the effects of nutrient inputs on the productivity of vegetables in Cabintan, ii) determine the effects of P application on improving P fertilizer efficiency and iii) demonstrate the influence of N. P and K application on the improvement of the productivity of soil and in increasing the yield of cabbage in Cabintan, Ormoc City, Philippines.

Results revealed that reducing the fertilizer cost by 50 percent in Treatment 3 as compared to the farmer's practice (Treatment 1) from P38, 404 to P 16, 750 would still give a yield comparable to the farmer's practice. Reduction of fertilizer inputs from 444-93-142 kg/ha N- P_2O_5-K_2O to 88-110-60 kg/ha N-P_2O_5-K_2O will lead to a better allocation of limited resource that is available to the farmers and more sustainable to the environment.

Key Words
Fertilizer cost, nutrient loading, nutrient balance

Introduction
Some of the major problems encountered by vegetable farmers in vegetable producing areas in the Southern Philippines are the inherent poor soil fertility and productivity, lack of appropriate technologies, improper water and soil conservation management and other production factors such as high cost of fertilizers and limited capital. The most dominant factors affecting vegetable production in Cabintan, Leyte, Philippines are the high cost of fertilizers and the very low amounts of phosphorus due to high P fixation in volcanic soils. To address this issue, a soil and participatory assessment survey was conducted in the area and the nutrient status of the soil was characterized. Based on the results of the soil analysis, a fertilizer trial was set-up in the area to establish the integrated nutrient management for cabbage production in an acid soil derived from volcanic ash.

The objectives of this study were to: i) study the effects of nutrient inputs on the productivity of vegetables in Cabintan, ii) determine the effects of P application on improving P fertilizer efficiency and iii) demonstrate the influence of N, P and K application on the improvement of the productivity of soil and in increasing the yield of cabbage in Cabintan, Ormoc City, Philippines. This will contribute to addressing the problem of the high cost of fertilizers being utilized by the farmers and most importantly the proper allocation of limited resources through the use of soil test results.

Methods
Site description
Cabintan is located approximately 18 km Northeast of Ormoc City with and elevation of around 900 m asl. Common land uses of the area are annual vegetable cropping (e.g. sweet peppers, cabbage, eggplant, tomatoes etc.), corn production and others are left to wild shrubs and forest tree species. The soil in mountainous area of Cabintan is mainly developed from volcanic tuff, basaltic and andesitic materials which were ejected during the period of active volcanism (Aurelio, 1992; Asio, 1996). The abundance of short ordered range of minerals in the soil of Cabintan may have worsened the high P-fixation capacity hence, phosphorus is one of the limiting factor for agricultural production. Agro climatic pattern of the study area indicated a wet climate with annual rainfall greater than 2500 mm, slight dry season moisture deficit, and a growing period of 270-320 days in hilly, mountainous to highland areas. Higher altitude of the area may however affected the agro-climatic pattern of the site hence intermittent rainfall is always observed throughout the growing season leading to a higher leaching rate of nutrients especially nitrogen.

Treatments and Experimental layout
The experimental area was laid out in a randomized complete block design (RCBD) with four treatments using cabbage (Green Helmit variety) replicated five times during the wet season of June to August, 2009. Alleyways of 0.5 m between treatment plots and 0.5 m between block were provided to facilitate farm management operation as well as data gathering. The treatments are shown in table 1.

Table 1. Nutrient concentration of fertiliser inputs (N:P_2O_5: K_2O), treatments nutrient loading and cost of fertilizer inputs.

Treatment	Fertiliser	Formulation	Rate	Weight	Cost	N	P_2O_5	K_2O	Cost
		(N:P_2O_5:K_2O)	(bags/ha)	(kg/bag)	(PHP/bag)	(kg/ha)			(PHP/ha)
T1 (Farmers practice)	Chicken Manure	(2.59-0.48-3.10)	75	25	100	49	9	58	7,500.00
	Complete	(14-14-14)	12	50	1200	84	84	84	14,400.00
	Urea	(16:20:0)	13.55	50	1218	311	0	0	16,503.90
					Total	444	93	142	38,403.90
T2	Ammophos	(16-20-00)	5.5	50	1200	44	55	0	6,600.00
	Muriate of Potash	(0-0-60)	1	50	1775	0	0	30	1,775.00
					Total	44	55	30	8,375.00
T3	Ammophos	(16-20-00)	11	50	1200	88	110	0	13,200.00
	Muriate of Potash	(0-0-60)	2	50	1775	0	0	60	3,550.00
					Total	88	110	60	16,750.00
T4	Ammophos	(16-20-00)	8.25	50	1200	66	82.5	0	9,900.00
	Muriate of Potash	(0-0-60)	1.5	50	1775	0	0	45	2,662.50
					Total	66	82.5	45	12,562.50

Soil sample collection, preparation and analysis
Soil sampling was done by collecting and compositing 10 subsamples from each sampling plot in surface (0-20 cm) soils. Composite samples were placed in properly labeled plastic bags. The samples were brought to the Soil's and Environment Laboratory, Philippine Root Crops and Training Centre, VSU, Visca, Baybay, Leyte.The collected samples were air-dried and sieved through a 2-mm wire mesh for the determination of soil's chemical properties. For organic matter determination, soil samples were passed through a 0.425-mm wire mesh. Thereafter, the samples were analyzed for the following soil parameters: Soil pH was determined potentiometrically using distilled water at a soil-solution ratio of 1:2.5 (ISRIC, 1995); OM and total N using modified Walkley-Black and modified Kjeldhal methods, respectively (USDA-NRCS, 1996); available phosphorus was extracted using the Bray No. 2 method of Jackson (1958) and Murphy and Riley (1962) for color development and quantified by measuring the percent absorbance at 880 nm using spectronic 20; cation exchange capacity (CEC) using 1 N NH_4OAc at pH 7 (USDA-NRCS, 1996). Exchangeable K, Ca, Na, and Mg were extracted by using 1 N NH_4OAc neutralized to pH 7 (USDA-NRCS, 1996); and then quantified by atomic absorption spectrophotometry (AAS).

Results and Discussion

Soil test results
The soil test results from field trial of cabbage grown during the wet season are presented in Table 2 indicating the very low fertility status of the soil. This is very evident in the amounts of P and exchangeable bases. However, the amounts of total organic C and total N are relatively higher which could be attributed to the high rates of application of chicken dung in the area.

Table 2. Soil test results from field trial during the wet season at Cabintan, Ormoc City (June – August, 2009).

Soil parameter	Pre-plant	Post-harvest			
		T1 (FP)	(T2)	(T3	(T4)
pH	5.01	4.82	4.88	4.81	4.55
Total Org. C (%)	5.24	-	-	-	-
Total N (%)	0.73	0.659	0.663	0.64	0.668
Extractable P (Bray P-2) (mg/kg)	5.19	6.030	6.218	5.000	5.505
Exchangeable K (cmol(+)/kg)	0.24	0.055	0.066	0.088	0.093
Exchangeable Ca (cmol(+)/kg)	0.21	0.434	0.362	0.338	0.347
Exchangeable Mg (cmol(+)/kg)	0.13	0.079	0.083	0.080	0.078
Exchangeable Na (cmol(+)/kg)	0.10	0.033	0.031	0.045	0.038
Cation Exchange Capacity (cmol(+)/kg)	0.68	0.601	0.542	0.551	0.556

Yield of Cabbage and Partial Nutrient Budget

The results of cabbage yield data presented in Table 3 indicated that superiority of the farmer's practice as compared to T_2 and T_3 which received reduced amounts of N and P fertilizers as compared to T_1 (Farmer's Practice) and T_3 (with the highest amounts of P applied). This result also implied the important roles of N, P and K in the development of cabbage being a leafy vegetable. These two treatments also have the highest amounts of nutrient removal and balance in the soil as indicated in Table 4. The method of fertilizer application is also very critical in a high rainfall area such as Cabintan since the applied fertilizers will be prone to high leaching losses. Among the 4 treatments, it is only in the farmer's practice that N was applied 3 times while in the alternative treatments, all the N was applied at planting.

Table 3. Cabbage yield results from field trial on cabbage during the wet season at Cabintan, Ormoc City (June - August, 2009).

Treatment	Marketable yield (t/ha)	Non-Marketable yield (t/ha)	Total Yield
T_1 (FP)	21.82[a]	2.21	24.03
T_2	6.16[c]	2.16	8.32
T_3	11.13[ab]	1.25	12.38
T_4	7.22[b]	1.08	8.298

Means with common letters and those without any letter designation are not significantly different at 5% level of significance based on LSD.

Table 4. Partial nutrient budget from field trial on cabbage during the wet season at Cabintan, Ormoc City (June - August, 2009).

Treatment	Nutrient loading			Nutrient Uptake			Nutrient removal			Nutrient balance		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	(kg/ha)			(kg/ha)			(kg/ha)			(kg/ha)		
T1 (FP)	444	93	142	5.26	27.34	2.44	100.64	0.05	38.65	343.36	92.95	103.35
T2	44	55	30	4.25	20.36	2.53	25.55	0.01	12.57	18.45	54.99	17.43
T3	88	110	60	4.11	23.27	2.55	39.97	0.02	20.52	48.03	109.98	39.48
T4	66	82.5	45	4.33	18.48	2.43	28.83	0.01	13.38	37.17	82.49	31.62

Gross Marginal Benefit

Reducing the cost of fertilizers by almost fifty percent from P38,403 to P16,750 likewise reduced the partial GMB for cabbage under Cabintan situation as presented in Table 5. Further reduction in fertilizer cost also indicated a reduction in the partial GMB obtained.

Table 5. Partial cost/benefit analysis of treatments used in the field experiment at Cabintan, Ormoc City (June - August, 2009).

Treatment	Fertiliser cost	Value of Marketable Yield**	Partial GMB
	(PHP/ha)		
T1 (FP)	38,403.90	654,488.52	616,084.62
T2	8,375.00	184,813.83	176,438.83
T3	16,750.00	333,842.13	317,092.13
T4	12,562.50	216,623.18	204,060.68

*Farm price at harvest was 30 PHP/kg.

Conclusions

The results of this study have provided evidence on the importance of fertilization in increasing the yield of cabbage in a volcanic ash soil in Cabintan, Ormoc City, Philippines. Increasing the amounts of N.P and K applied in the soil will also have tremendous effect on the yield of the crop. These findings signify the important contribution of macronutrients on the yield of cabbage under wet season. It is also recommended to plant cabbage under the dry season to assess the effects of the alternative treatments on the crop.

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