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Increasing Cabbage Production Through NPK Application In Cabintan, Ormoc City, 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 on the nutrient status of the soil. This study determined the effects of P application on P fertilizer efficiency and demonstrated the influence of N, P and K application in increasing the yield of cabbage (*Brassica oleracea* L.)in Cabintan, Ormoc City, Philippines. The treatments included: T_1- Farmers' practice consisting of chicken manure (75 bags/ha) + Complete (12 bags/ha) + Urea (13.5 bags/ha); T_2- Ammophos (5.5 bags/ha) + Muriate of Potash (1 bag/ha); T_3- Ammophos (11 bags/ha) + Muriate of Potash (2 bags/ha); T_4- Ammophos (8.25 bags/ha) + Muriate of Potash (1.5 bags/ha). The study demonstrated the importance of applying appropriate levels of NPK fertilizers in improving the growth and yield of cabbage. It also revealed that reducing the fertilizer costs by 50 percent in Treatment 3 as compared to the farmer's practice in Treatment 1 (i.e. from P38,400 to P16,800) would give a more sustainable yield as compared 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 in T_3 will lead to a better allocation of limited resource that is available to the farmers.

Key Words: fertilizer costs, nutrient loading, nutrient balance, levels of NPK fertilizers, cabbage yield

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INTRODUCTION

Improving soil quality for better crop production has long been a primary objective of soil science, but many problems of soil quality remain. For example, soil quality degradation due to the mismanagement of soil resources and soil properties have changed as a result of intensive continuous cropping, monoculture, and the heavy use of agrochemicals (e.g. pesticides and inorganic fertilizers). To address this issue, sustainable soil nutrient-enhancing strategies such as the integrated nutrient management (INM) which involve the wise use and management of inorganic and organic nutrient sources in ecologically sound production systems (Janssen, 1993) were applied.

The primary goal of integrated nutrient management 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. 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).

The usual recommended rates for fertilizers were set to assume that the soil fertility is low, so it is not appropriate to apply these to the continuously cultivated soils due to its increasing residual fertility (Jung and Yoo, 1991). The accumulation of some nutrient elements in soil is already evident, and it is time to re-evaluate soil fertility. If there is an excess of soil nutrients, the surplus will not be taken by plants anymore but could be lost by denitrification and/or by leaching for N, fixation for K and P (Saito, 1991). Thus, a correct assessment of the amount of available nitrogen, phosphorus, potassium as well as the level of micronutrients based on soil testing, is therefore highly desirable.

A scoping study undertaken by some ACIAR scientists in November 2007 identified the following key issues with respect to soil and crop nutrient management in vegetable production systems in Northern Mindanao and the Eastern Visayas (Leyte). These include declining soil fertility, high costs of inorganic fertilizers and a lack of grower capital, shift towards more "organic" production, availability of organic materials, lack of information and training, and the widespread prevalence of soil borne disease. In addition, some of the major problems encountered by vegetable farmers in vegetable producing areas in Leyte 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.

In Cabintan, Ormoc City, Leyte, the most dominant factors affecting vegetable production are the high cost of fertilizers due to very high rates of fertilizer application by the farmers and the very low amount of available soil P due to high P fixation in volcanic soils. To address this issue, a 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 to establish the integrated nutrient management for cabbage production in an acid soil derived from volcanic ash. It was hypothesized that these fertilizer treatments which included the current farmers' practice and the other alternative treatments to be introduced will contribute to addressing the major problems confronting vegetable farmers. Hence, the objectives of this study were to i) evaluate the effects of nutrient inputs on the productivity of cabbage (*Brassica oleracea* L.), ii) determine the effects of P application on improving P fertilizer efficiency and iii) demonstrate the influence of varying levels of N, P and K application in increasing the yield of cabbage in Cabintan, Ormoc City, Philippines.

MATERIALS AND METHODS

Site description

Cabintan is a mountainous area located approximately 18 km Northeast of Ormoc City at an elevation of around 900 m above sea level (Fig. 1). Common land uses of the area are annual vegetable cropping (e.g. sweet pepper, cabbage, eggplant and tomato), corn production as well as forest land use. The soil 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 minerals in the soil of Cabintan causes the high soil P-fixation capacity; hence, P is one of the limiting factors for agricultural production.

Agro-climatic pattern of the study area indicates a wet climate with an 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 (Fig. 1). The higher altitude of the area affects the agro-climatic pattern of the site which is the reason why intermittent rainfall is always observed throughout the growing season leading to a higher leaching rate of nutrients especially N.

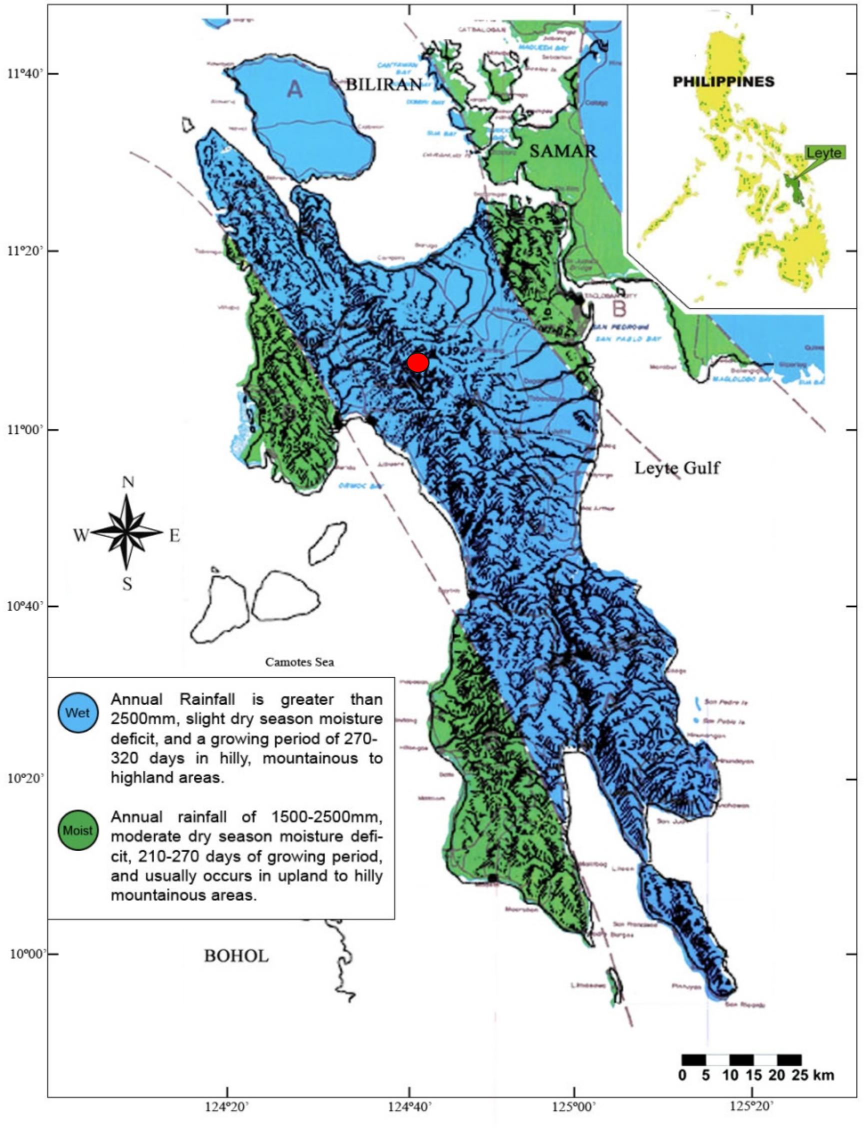

Figure 1. Location of the study site at Cabintan, Ormoc City (indicated by a red dot) and the agro-climatic map of Leyte

Preparation of planting medium, transplanting and care and management

To prepare the planting medium, a mixture of aged rice hull, compost and garden soil at 1:1:1 (v/v) ratio was screened to remove stones and other undecomposed materials. The process of pasteurization was done and completed for a period of approximately 2-3 hours. The prepared soil medium was used for sowing the cabbage seeds which were allowed to grow until pricking stage.

Cabbage seedlings (Green Helmit variety) were transplanted at the rate of one seedling per hill three weeks after emergence. To keep the germination medium intact with the root system, the germination cell was removed carefully before planting the seedling in the growth medium (Fig. 2). The plants were provided adequately with water as well as spared from weed competition. Watering and hand weeding, therefore, were done when deemed necessary. The plants were sprayed with insecticide and fungicide to control insect pest and fungal diseases. Spraying was done starting from third week after transplanting up to the start of heading.

Figure 2. Field preparation and planting of cabbage for the field fertilizer trial

Tissue sample collection, preparation and analysis

Leaf samples were collected 30 days after transplanting and at harvest period. Leaf samples were washed with deionized water, blotted dry with tissue paper and air dried. The leaves were then oven-dried at 70°C for at least 2 days. The dried leaves were then ground using Willey mill and placed in labelled paper bags for analysis. Total concentration of P and K in the plant samples were analyzed by first dry ashing them at 500°C for a minimum of 5 hours (but not exceeding 16 hours) followed by the addition of 6 M hydrochloric acid. Quantification of K was done using an atomic absorption spectrophotometer while P was analyzed using a UV-VIS spectrometer. Total N was analyzed by Kjeldal method involving sample digestion with concentrated H_2SO_4, distillation and titration (ISRIC, 1995).

Experimental layout

The experimental area was laid out in the field in a randomized complete block design (RCBD) with four treatments replicated five times during the wet season of June to August, 2009 (Fig. 3). 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 were as follows: T1 - Farmers' practice consisting of chicken mnaure (75 bags/ha) + Complete (12 bags/ha) + Urea (13.5 bags/ha); T2 - Ammophos (5.5 bags/ha) + Muriate of potash (1 bag/ha); T3 - Ammophos (11 bags/ha) + Muriate of potash (2 bag/ha); T4 - Ammophos (8.25 bags/ha) + Muriate of potash (1.5 bags/ha). These rates translate to the following: 444-93-142 kg/ha N-P_2O_5-K_2O for T1 (farmer's practice); 44-55-30 kg/ha N-P_2O_5-K_2O for T2; 88-110-60 kg/ha N-P_2O_5-K_2O for T3; and 66 - 82.5 - 45 kg/ha N-P_2O_5-K_2O for T4. More detailed information on the treatments can be found in Table 1.

Figure 3. The newly established field trial one week after transplanting cabbage at Cabintan, Ormoc City, Philippines

Soil sample collection, preparation and analysis

Soil sampling was done by collecting and compositing 10 subsamples from the surface soil (0-20 cm) of each sampling plot. Composite samples were placed in labelled plastic bags and brought to the Soil and Environment Laboratory, Philrootcrops, VSU, Baybay City, Leyte. The collected samples were air-dried and sieved through a 2-mm wire mesh for the determination of soil chemical properties. For organic matter (OM) determination, soil samples were passed through a 0.425-mm wire mesh.

Soil samples were analysed 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 Kjeldal methods, respectively (USDA-NRCS, 1996); available P by the Bray No. 2 method of Jackson (1958), color development by Murphy and Riley (1962), and quantified by measuring the percent absorbance at 880 nm using Hitachi UV-Vis Spectrophotometer; 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). These were quantified by atomic absorption spectrophotometry (Varian Spectra AA 220 FS) (Westerman, 1990).

RESULTS AND DISCUSSION

Soil Nutrient Status

The soil test results from the cabbage field trial during the wet season indicate a low fertility status of the soil in the experimental site (Table 2). The soil is strongly acidic, has low cation exchange capacity, and contains very low available P and exchangeable bases which can be expected since the soil is a young volcanic soil (Andisol). However, the soil contains high amounts of total N which could be attributed to the high rates of chicken manure application by the farmers in the area.

The soil test results were used as basis in the design of the treatments and fertilizer levels that were applied considering the inherent fertility status of the soil. This is very important in assessing nutrient imbalances and toxicities in soils and this practice is often ignored by farmers since they normally do not have access to soil analysis. In most instances, the farmers just apply very high levels of fertilizers for vegetable production

Table 1. Description of the treatments used in the field trial at Cabintan, Ormoc City, Philippines

Treatments	Fertilizer	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
	Complete	(14-14-14)	12	50	1200	84	84	84	14,400
	Urea	(46-0-0)	13.55	50	1218	311	0	0	16,500
					Total	444	93	142	38,400
T2	Ammophos	(16-20-00)	5.5	50	1200	44	55	0	6,600
	Muriate of Potash	(0-0-60)	1	50	1775	0	0	30	1,800
					Total	44	55	30	8,400
T3	Ammophos	(16-20-00)	11	50	1200	88	110	0	13,200
	Muriate of Potash	(0-0-60)	2	50	1775	0	0	60	3,600
					Total	88	110	60	16,800
T4	Ammophos	(16-20-00)	8.25	50	1200	66	82.5	0	9,900
	Muriate of Potash	(0-0-60)	1.5	50	1775	0	0	45	2,700
					Total	66	82.5	45	12,600

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

3Ø©∞º≤≠•¥≤	Pre-plant	Post-harvest			
		T1 (FP)	T2	T3	T4
pH (water)	5.01	4.82	4.88	4.81	4.55
Total N (%)	0.73	0.66	0.66	0.64	0.67
Extractable P (Bray P-2) (mg/kg)	5.19	6.03	6.22	5.00	5.51
Exchangeable K (cmol(+)/kg)	0.24	0.05	0.07	0.09	0.09
Exchangeable Ca (cmol(+)/kg)	0.21	0.43	0.36	0.34	0.35
Exchangeable Mg (cmol(+)/kg)	0.13	0.08	0.08	0.08	0.08
Exchangeable Na (cmol(+)/kg)	0.10	0.03	0.03	0.05	0.04
Cation Exchange Capacity (cmol(+)/kg)	19.14	17.82	18.02	18.32	16.83

Treatments: T1- Farmers' practice consisting of chicken manure (75 bags/ha) + Complete (12 bags/ha) + Urea (13.5 bags/ha); T2- Ammophos (5.5 bags/ha) + Muriate of Potash (1 bag/ha); T3- Ammophos (11 bags/ha) + Muriate of Potash (2 bags/ha); T4- Ammophos (8.25 bags/ha) + Muriate of Potash (1.5 bags/ha).

without considering the amount of nutrients that are still present in the soil which could be taken up by the crop.

Plant Height and Yield of Cabbage

Figure 4 presents the average plant height of cabbage as influenced by the different treatments. Results showed that plants in T_1 were the tallest which can be expected since this treatment also had the highest rate of nutrient application. T_3 produced the second tallest plants which can be due to the fact that this treatment supplied the second highest amounts of nutrients. This result implies the necessity of applying high amounts of fertilizers to improve the growth and yield of cabbage in Cabintan which has an infertile soil.

Table 3 presents the cabbage yield indicating the superiority of the farmer's practice (T_1) as compared to T_2 and T_3 which received reduced amounts of N and P fertilizers. This result also implies the important roles of N, P and K in the development of cabbage being a leafy vegetable. Foliar nutrient concentrations of cabbage at peak uptake (30 days after transplanting) as well as at harvest are presented in Table 4. Results revealed that at peak uptake, T_1 has the highest uptake followed by T_3, T_4 and T_2. Tissue concentration of cabbage at peak uptake is a very important indicator of the soil's capacity to supply nutrients to the crop as well as to evaluate and monitor the nutrients being utilized by the crop whether it is sufficient or not. Based on the result, the N, P and K concentrations fall within the optimum ranges for plants at 30 days after transplanting and at harvest period. As reported by Marschner (1995), the optimum levels for N in plants range from 2 to 5%; for P, it ranges from 0.18 to 0.25%; and for K, it ranges from 2 to 5 %.

The results suggest that application of the different fertilizer treatments resulted in sufficient NPK levels in the leaf of cabbage.

Gross Marginal Benefit

Table 5 shows the partial cost/benefit analysis of the various treatments used. From the data, it is evident that by reducing the cost of fertilizers by almost fifty percent from P 38,400 to P 16,800, there was a corresponding reduction in the partial Gross Marginal Benefit (GMB) for cabbage production under the prevailing conditions in Cabintan. Further reduction in fertilizer cost also resulted in the reduction in the partial GMB obtained. These data also give us an idea on the important contribution of each treatment combinations on the growth and yield of cabbage.

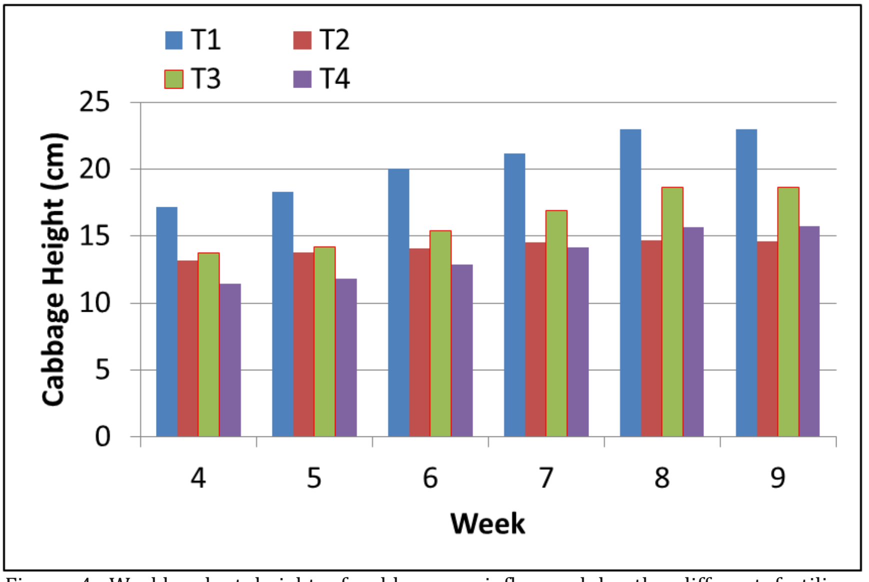

Figure 4. Weekly plant height of cabbage as influenced by the different fertilizer treatments. T_1- Farmers' practice consisting of chicken manure (75 bags/ha) + Complete (12 bags/ha) + Urea (13.5 bags/ha); T_2- Ammophos (5.5 bags/ha) + Muriate of Potash (1 bag/ha); T_3- Ammophos (11 bags/ha) + Muriate of Potash (2 bags/ha); T_4- Ammophos (8.25 bags/ha) + Muriate of Potash (1.5 bags/ha)

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

4≤°¥•Æ¥	Marketable yield (t/ha)	Non-Marketable yield (t/ha)	Total Yield (t/ha)
T_1 (FP)	21.8^a	2.2	24.0^a
T_2	6.2^c	2.2	8.3^c
T_3	11.1^{ab}	1.3	12.3^{ab}
T_4	7.2^b	1.1	8.3^b

Means with common letters and those without any letter designation are not significantly different at 5% level of significance based on LSD.
Treatments: T_1- Farmers' practice consisting of chicken manure (75 bags/ha) + Complete (12 bags/ha) + Urea (13.5 bags/ha); T_2- Ammophos (5.5 bags/ha) + Muriate of Potash (1 bag/ha); T_3- Ammophos (11 bags/ha) + Muriate of Potash (2 bags/ha); T_4- Ammophos (8.25 bags/ha) + Muriate of Potash (1.5 bags/ha).

Table 4. Foliar nutrient concentrations of cabbage from the field experiment at Cabintan, Ormoc, City (June - August 2009)

Treatment	Tissue concentration at peak uptake* (%)			Tissue concentration in harvestable portion (%)		
	N	P	K	N	P	K
T1 (FP)	4.76	0.27	1.03	5.26	0.27	2.44
T2	4.02	0.20	0.84	4.25	0.20	2.53
T3	4.31	0.23	0.86	4.11	0.23	2.55
T4	4.22	0.18	0.63	4.33	0.18	2.43

s.d.(n=5) * at 30 days after transplanting

Treatments: T_1- Farmers' practice consisting of chicken manure (75 bags/ha) + Complete (12 bags/ha) + Urea (13.5 bags/ha); T_2- Ammophos (5.5 bags/ha) + Muriate of Potash (1 bag/ha); T_3- Ammophos (11 bags/ha) + Muriate of Potash (2 bags/ha); T_4- Ammophos (8.25 bags/ha) + Muriate of Potash (1.5 bags/ha).

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

Treatment	Fertilizer cost (PHP/ha)	Value of Marketable Yield**	Partial GMB
T1 (FP)	38,400	654,500	616,100
T2	8,380	184,800	176,400
T3	16,800	333,800	317,100
T4	12,600	216,600	204,100

**Farm price at harvest was 30 PHP/kg. GMB- gross marginal benefit

Treatments: T_1- Farmers' practice consisting of chicken manure (75 bags/ha) + Complete (12 bags/ha) + Urea (13.5 bags/ha); T_2- Ammophos (5.5 bags/ha) + Muriate of Potash (1 bag/ha); T_3- Ammophos (11 bags/ha) + Muriate of Potash (2 bags/ha); T_4- Ammophos (8.25 bags/ha) + Muriate of Potash (1.5 bags/ha).

CONCLUSIONS

The study demonstrated the importance of applying appropriate levels of NPK fertilizers in improving the growth and yield of cabbage in the volcanic ash soil of Cabintan, Ormoc City, Philippines. Reducing the fertilizer cost by 50 percent relative to the farmer's practice (i.e. from P38, 400 to P16, 800) would still give a yield comparable to that of 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. Increasing the amounts of P applied to the soil enhanced the P fertilizer efficiency in the volcanic ash soil.

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