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SOIL FERTILITY STATUS OF MAJOR AGRICULTURAL AREAS IN THE SEVEN MUNICIPALITIES OF BENGUET

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ABSTRACT

The major agricultural soils of the seven municipalities of Benguet namely: Bokod, Itogon, Kabayan, Kapangan, La Trinidad, Sablan and Tuba were assessed of their fertility status to develop maps reflecting the soil fertility and develop fertilizer recommendation for specific crop grown and lime requirement of the acidic soil from March 2010 to December 2011. One composite sample representing the different soil series from the seven municipalities were collected and analyzed for soil pH; organic matter (OM); soil nutrients available phosphorus (P) and exchangeable potassium (K); and cation exchange capacity (CEC).

Results show that majority of the agricultural soils in Kabayan, La Trinidad, Sablan and Tuba have strongly acidic soils unfavorable for crop production. Only the soils of Bokod, Itogon and Kapangan are moderately favorable to favorable although some sampling sites of the areas have pH values below 5.0.

Agricultural soils of Kapangan have deficient organic matter and soil nutrient phosphorus whereas soils in the municipalities of Bokod, Itogon, Kabayan, La Trinidad, Sablan and Tuba have moderate amounts of organic matter and phosphorus. Soils in Bokod, Kabayan, La Trinidad and Tuba have moderate amount of soil nutrient K while soils of Itogon, Kapangan and Sablan are deficient of the element. The cation exchange capacity of the soils are adequate in all the soils studied in the seven municipalities of Benguet.

Based from the results of soil analysis soil fertility maps per municipality and fertilizer recommendation for specific crops grown including the lime requirement of acid soils were produced.

Keywords: *soil nutrient, soil series, lime requirement and soil fertility status*

INTRODUCTION

Intensive farming removes most of the nutrients from the soil. A cabbage yield of 70 t ha^{-1} when harvested can remove 200 kg ha^{-1} nitrogen (N), 90 kg ha^{-1} phosphorus (P) and 320 kg ha^{-1} potassium (K) from the soil; potato yield of 10-18 t ha^{-1} can remove 50-80 N kg ha^{-1}, 20-30 kg ha^{-1} P and 60-140 kg ha^{-1} K; and carrot with a yield of 40 t ha^{-1} remove 106 kg ha^{-1} N, 52 kg ha^{-1} P and 220 kg ha^{-1} K (PCARRD,1986).

To replenish the soil nutrients, application of fertilizers is employed in order to sustain good yield. However, continuous application of heavy dosage of inorganic fertilizers and raw chicken manure may lead to soil degradation in terms of soil acidity and pollution of the underground and surface water resources. In addition, the occurrence of soil-borne diseases may aggravate the problem as a result of poor soil conditions.

In Benguet and some parts of Mountain Province,

farmers apply fertilizers more than what the crops require. Mayao *et al*., (2004) found that Mankayan farmers of Benguet apply about 460-168-168 kg ha^{-1} N-P2O5-K2O for cabbagewhich is more than what the crop need (240-60-60 kg ha^{-1} N-P2O5-K2O). As a result, various soil problems occur like soil acidity, soil compaction and occurrence of plant diseases like clubroot for crucifers.

Atok soils grown with vegetable for a number of years have soil pH ranging from 4.3-4.9 (Alfredo, 1996); Mankayan soils, 4.0-4.7 (Faroden, 1997) and Buguias soils, 4.1-5.2 (Cabaling and Fagyan, 2007). The low soil pH can be observed in other areas where intensive crop cultivation is being practiced.

Farmers in Benguet also apply lime to correct soil acidity, control clubroot and to know the effect of lime without knowing the lime requirement of acid soils (Faroden, 1996).

Objectives

The study aimed to assess the soil fertility status of farmlands in the municipalities of Bokod, Itogon, Kapangan, Kabayan, La Trinidad, Sablan and Tuba; develop maps reflecting the soil fertility status for each municipality; develop fertilizer recommendation specific only to crops grown on each municipality and assess lime requirements of the acidic soils.

MATERIALS AND METHODS

The research involved field survey and sampling and laboratory analyses to gather the necessary data on the chemical properties of the agricultural areas in the municipalities of Bokod, Itogon, Kabayan, Kapangan, La Trinidad, Sablan and Tuba, Benguet (Figure 1).

Soil Sampling

Representative farms representing the different

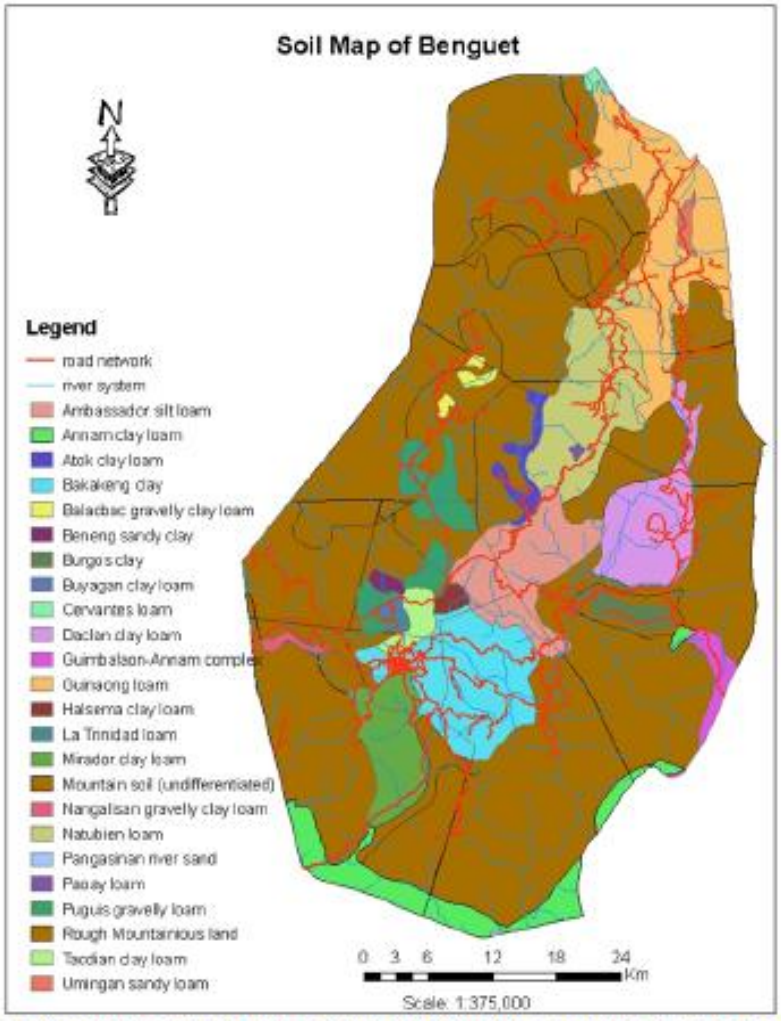


Figure 1. Location and soil map of Benguet Province showing the study area and soil series where soil samples were collected

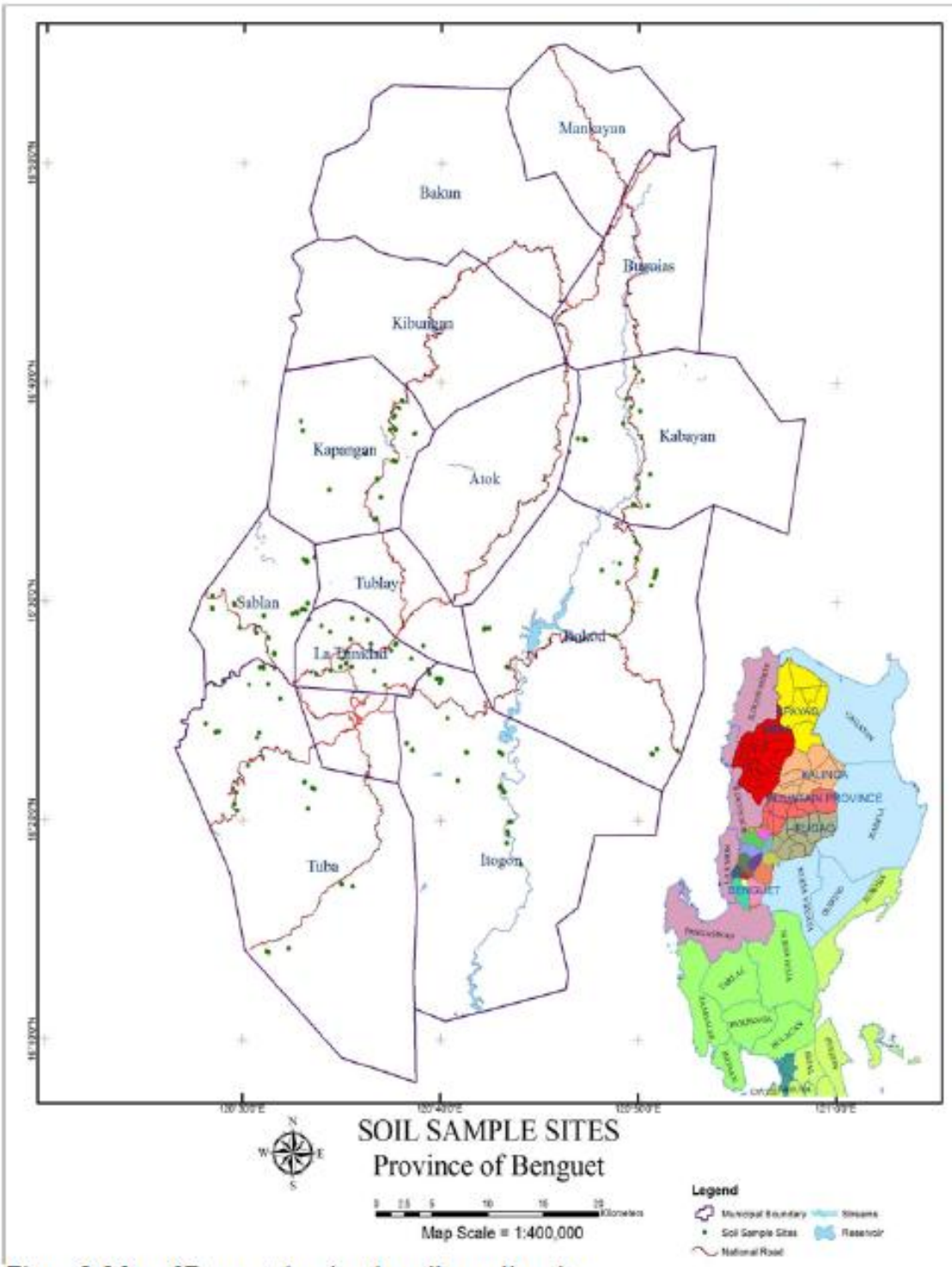


Figure 2. Map of Benguet showing the soil sampling sites

soil series per municipality were selected with the help of the Local government unit (LGU's) to represent the major agricultural areas per municipality. Composite topsoil samples at 0-20 cm depth were taken (Figure 2) from March to October 2010. Simultaneous with soil sampling, coordinates and elevations of the sampling sites were taken with the use of the Global Positioning System (GPS). The GPS readings were recorded for each sampling site as basis for the preparation of soil fertility maps per municipality.

Environmental conditions including existing vegetation in the sampling sites were recorded. The soil samples collected were brought to the Benguet Provincial Soils Laboratory for air drying. Each soil sample was pulverized for soil analysis.

Soil Analysis

The soil samples were analyzed for the following chemical properties: pH value, Organic Matter (OM), phosphorus (P), potassium (K) content; and Cation Exchange Capacity (CEC). Soil samples with pH below 5 were determined of its lime requirement.

Soil Fertility Map Preparation

The soil fertility maps were prepared using the soil maps from the seven municipalities earlier prepared by the University of the Philippines Los Baños (UPLB). The data on soil chemical properties of representative farms per municipality were plot on the map.

RESULTS AND DISCUSSION

Soil Fertility Status of the Major Agricultural Soils in the Seven Municipalities of Benguet

Soil pH

Soil reaction refers to the degree of acidity or alkalinity of the soil expressed as the pH value. The scale is from 1 to 14. A pH value of seven indicates neutrality and figures below seven indicate acid soil while higher value indicates alkalinity (Plaster, 1997).

Vegetables and root crops grow bestunder soils with pH values between five and seven while onions and Baguio beans require pH values from 5.4 to 6.8 (PCARRD, 1986).

Table 1 presents the pH levels of the major agricultural soils in the seven municipalities of Benguet. Majority of the agricultural soils in the representative farms have less than 5 pH values which is considered unfavorable soil reaction for crop production. Only agricultural soils of Bokod, Itogon and Kapangan have moderately favorable to favorable soil reaction with pH ranging from 5.0 to 6.5 although some sampling sites have pH values below 5.0. Agricultural soils of Kabayan, La Trinidad, Sablan and Tuba have pH values of 4.2 to 4.9 indicating a strongly acidic soil which are unfavorable for crop production, hence need liming to correct the pH level (Table 1 and Figure 3). Considering the current soil pH status of the representative farms, the lime requirements of the agricultural soils to raise the pH to 6 and 6.5 per municipality are presented in Table 2a-2g.

Organic Matter

The organic matter (OM) content of the soil is an indication of the level of nitrogen (N) present. Thus, adequate OM content would mean an adequate level of N. It also means that the soil has better tilth, aeration and drainage and higher water holding capacity, providing sufficient moisture for plant and microorganisms during the dry season and lesser erosion due to less volume of run-off.

Based on the laboratory results, the OM content of the agricultural soils in the seven municipalities is moderately favorable except for Kapangan with deficient OM (Table 3). The results indicate the need to further improve or maintain the OM content of the agricultural soils in order to sustain crop production. This is because organic matter is an important reservoir of nutrients (Foth, 1990) and serves as a granulating agent in soils, provides structural stability and optimum air and water, darkens the soil causing it to absorb heat (Kommedahl and Williams, 1983). Application of compost results in humus formation and promotes good structure (Thompson, 1973).

Available phosphorus

Phosphorus is one of the major nutrient elements needed for plant growth. A deficiency of the element results in stunted growth and purplish-green petiole of crucifers and leaves of legumes.

Based on laboratory results, the phosphorus level of the agricultural soils in the seven municipalities ismoderately favorable except for Kapangan which has deficient phosphorus (Table 4). Soil containing P content within 30-40 ppm is reasonably sufficient for plant growth (PCARRD, 1982). In this study, all of the agricultural soils analyzed have lower than 30 ppm available P.

Table 1. Soil pH of the major agricultural soils in the seven municipalities of Benguet

	Municipality						
Soil Type	Bokod	Itogon	Kabayan	Kapangan	La Trinidad	Sablan	Tuba
Ambassador Si.L	5.0-5.5	4.6-5.9			4.2-4.8		
Bakakeng C		3.7-6.5			4.5-4.8		
Balakbak Gr. L				4.9-5.7			
Bineng SC					4.7-4.9		
Burgos C							
Buyagan CL					5.7-6.0		
Daclan CL	4.3-5.2		4.7-5.0				
Guimbalaoan-Annam Complex	5.0-5.9						
Guinaoang L			4.8-5.6				
Halsema L					4.4-4.8		
La Trinidad L					5.2-6.0		
Mirador CL							
Mountain Soil Undifferentiated	4.6-4.9	4.6-5.8	4.7-5.3	4.4-6.6	4.2-4.9	4.0-4.8	4.3-5.7
Nangalisan Gr. L							
Natubleng L			4.7-5.3				
Puguis Gr. L				4.9-6.2	4.5-5.8	4.6	
Rough Mtn L				4.4-6.4		4.0-5.4	4.5-5.4
Tacdian CL					5.2-5.4		

Fertility Rating (BSWM):
Favorable: 5.5 – 8.5 Moderate: 5.0 – 5.5 Unfavorable: <5

Table 2a. Lime requirement of the major agricultural soils in Bokod with pH below 5.0

Soil Type	Starting pH level	Lime requirement (calcium hydroxide) to raise pH to:	
		6	6.5
Daclan Clay Loam (DCL)	4.3-4.6	2,960	5,920
	4.8-4.9	2,960	5,920
Mountain Soil Undifferentiated (MSU)	4.6	2,960	8,880
	4.8-4.9	2,960	5,920

Table 2b. Lime requirement of the major agricultural soils in Itogon with pH below 5

Soil Type	Starting pH level	Lime requirement (calcium hydroxide) to raise pH to:	
		6	6.5
Ambassador Silt Loam	4.6-4.7	2,960	5,920
Mountain Soil Undifferentiated (MSU)	3.7	5,920	8,880
	4.1-4.2	2,960	5,920
	4.8	2,960	5,920
Mountain soil Undifferentiated (MSU)	4.6	2,960	8,880
	4.7-4.8	2,960	8,880

Table 2c. Lime requirement of major agricultural soils in Kabayan with pH below 5.0

Soil Type	Starting pH level	Lime requirement (calcium hydroxide) to raise pH to:	
		6	6.5
Daclan Clay Loam (DCL)	4.7-4.9	2,960	5,920
Ginaoang Loam	4.8	2,960	5,920
Natubleng Loam	4.7-4.9	5,920	8,880

Table 2d. Lime requirement of soils in Kapangan with pH below 5

Soil Type	Starting pH level	Lime requirement (calcium hydroxide) to raise pH to:	
		6	6.5
Balakbak Gravelly loam	4.9	2,960	8,880
Mountain Soil Undifferentiated (MSU)	4.4	5,920	8,880
Puguis Gravelly Loam	4.8-4.9	2,960	8,880
Rough Mountain Land (RML)	4.4-4.5	5,920	8,880
	4.9	2,960	8,880

Table 2e. Lime requirement of the major agricultural soils in La Trinidad

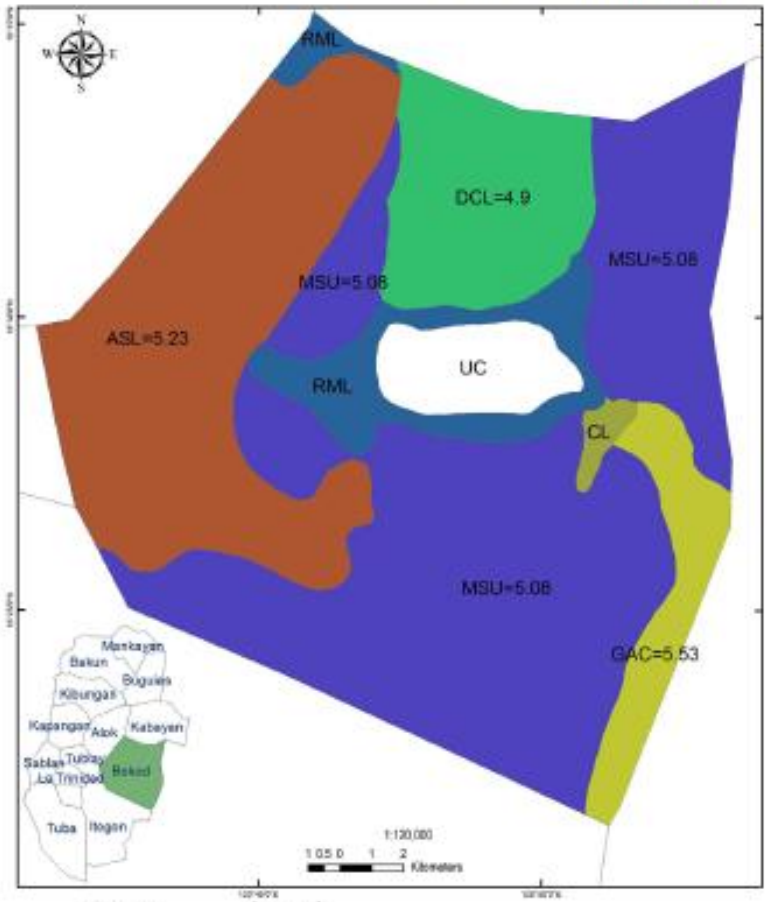
Soil Type	Starting pH level	Lime requirement (calcium hydroxide) to raise pH to:	
		6	6.5
Ambassador Silt Loam	4.8	2,960	5,920
Bakakeng Clay	4.5	2,960	5,920
	4.8	2,960	5,920
Bineng sandy Clay	4.7-4.9	2,960	8,880
Halsema Loam	4.4-4.6	5,920	11,840
	4.8	2,960	8,880
Puguis Gravelly Loam	4.5	5,920	11,840
Mountain Soil Undifferentiated	4.2	2,960	8,880
	4.9	2,960	5,920

Table 2f. Lime requirement of major agricultural soils in Sablan

Soil Type	Starting pH level	Lime requirement (calcium hydroxide) to raise pH to:	
		6	6.5
Burgos Clay	4.8	2,960	8,880
Puguis Gravelly Loam	4.60	5,920	8,880
	4.0-4.40	5,920	11,840
Mountain Soil Undifferentiated	4.50	2,960	8,880
	4.7-4.9	2,960	5,920
Rough Mountain land	4.0-4.40	5,920	8,880
	4.5-4.6	2,960	5,920
	4.7-4.9	2,960	5,920

Table 2g. Lime requirement of soils with pH below 5 in Tuba

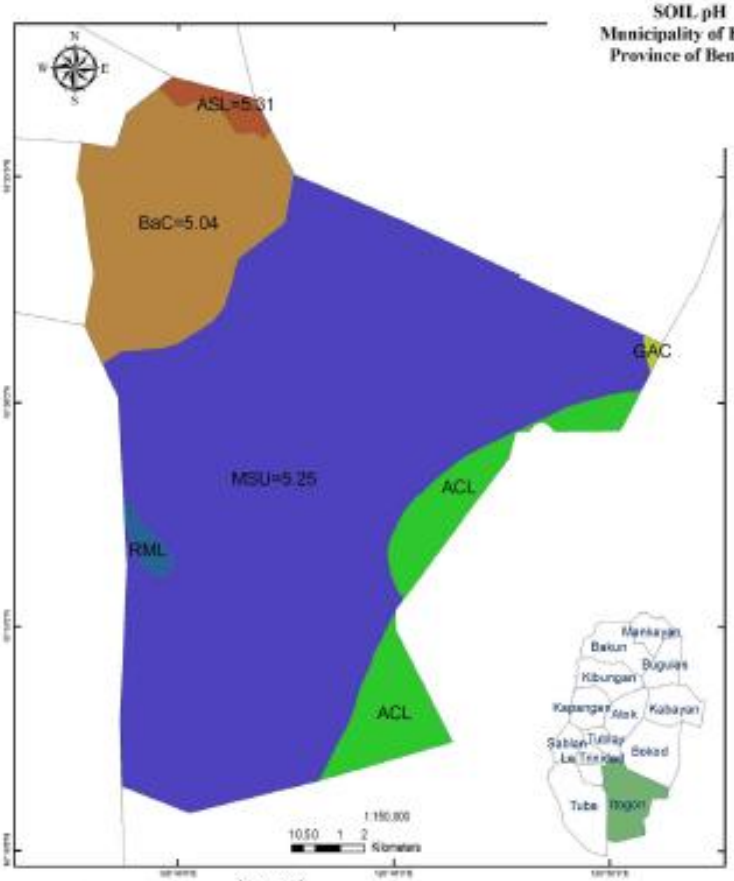
Soil Type	Starting pH level	Lime requirement (calcium hydroxide) to raise pH to:	
		6	6.5
Mirador Clay Loam	4.20	2,960	8,880
Mountain Soil Undifferentiated	4.3-4.5	2,960	8,880
	4.6-4.9	2,960	5,920
Nangalisan Gravelly Loam	4.8-4.9	2,960	5,920
Rough Mountain land	4.5-4.9	2,960	5,920



SOIL pH
Municipality of Bokod
Province of Benguet

Legend

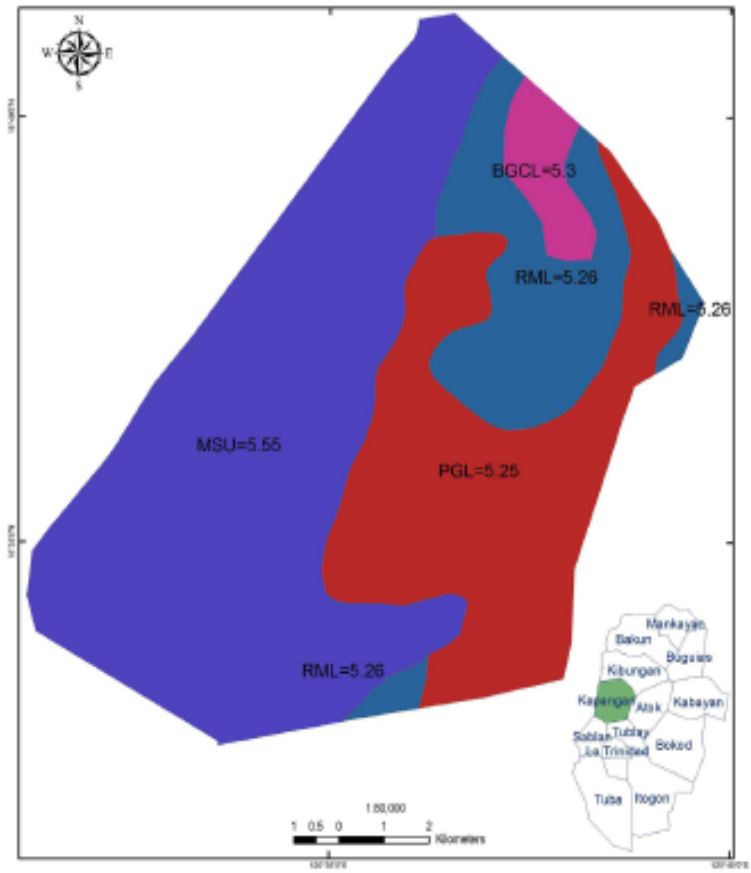
Municipal Boundary
ASL-Ambassador Silt Loam
CL-Cervantes Loam
DCL-Daclan Clay Loam
GAC-Guimbalaon- Annam Complex
MSU-Mountain Soil Undifferentiated
RML-Rough Mountainous Land
UC-Unclassified



SOIL pH
Municipality of Itogon
Province of Benguet

Legend

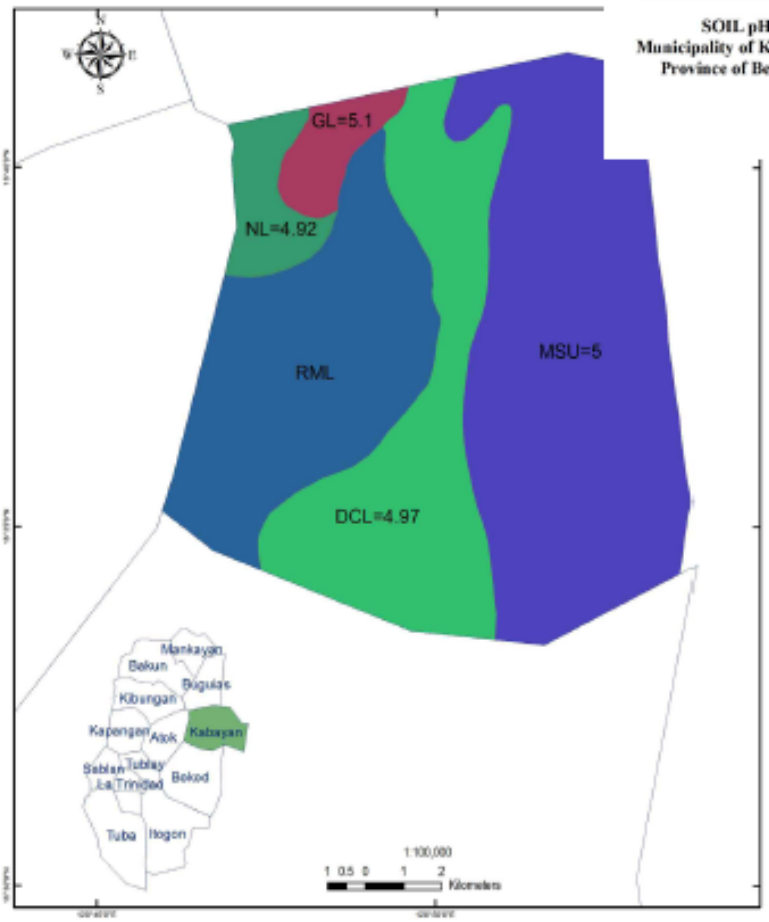
Municipal Boundary
ACL- Annam Clay Loam
ASL-Ambassador Silt Loam
BaC-Bakakeng Clay
GAC-Guimbalaon- Annam Complex
MSU-Mountain Soil Undifferentiated
RML-Rough Mountainous Land



SOIL pH
Municipality of Kapangan
Province of Benguet

Legend

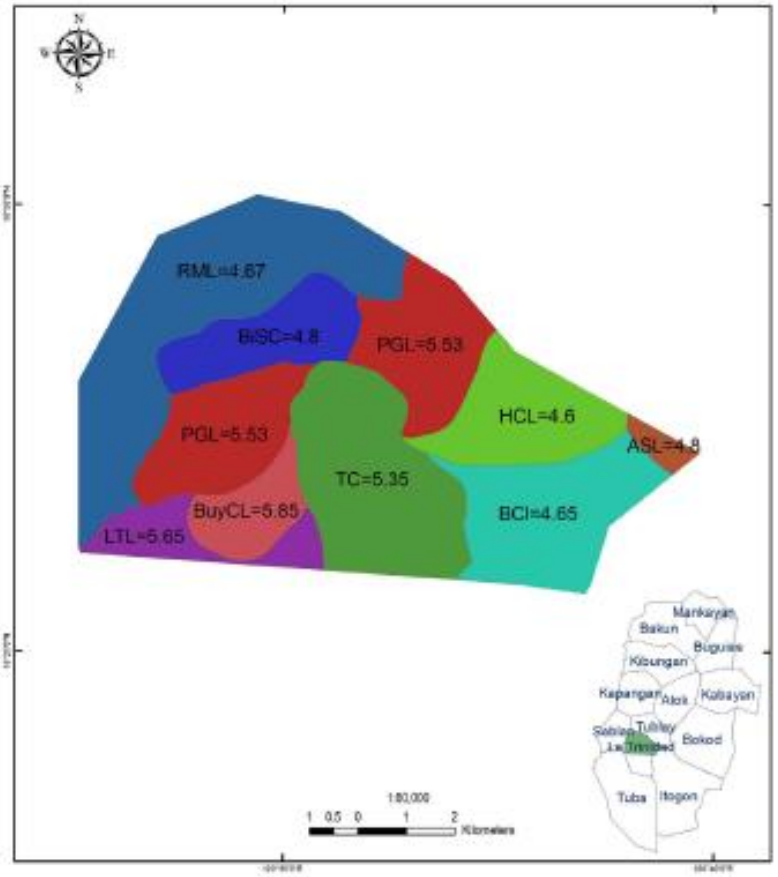
BGCL-Balakbac Gravelly Clay Loam
MSU-Mountain Soil Undifferentiated
PGL-Puguis Gravelly Loam
RML-Rough Mountainous Land



SOIL pH
Municipality of Kabayan
Province of Benguet

Legend

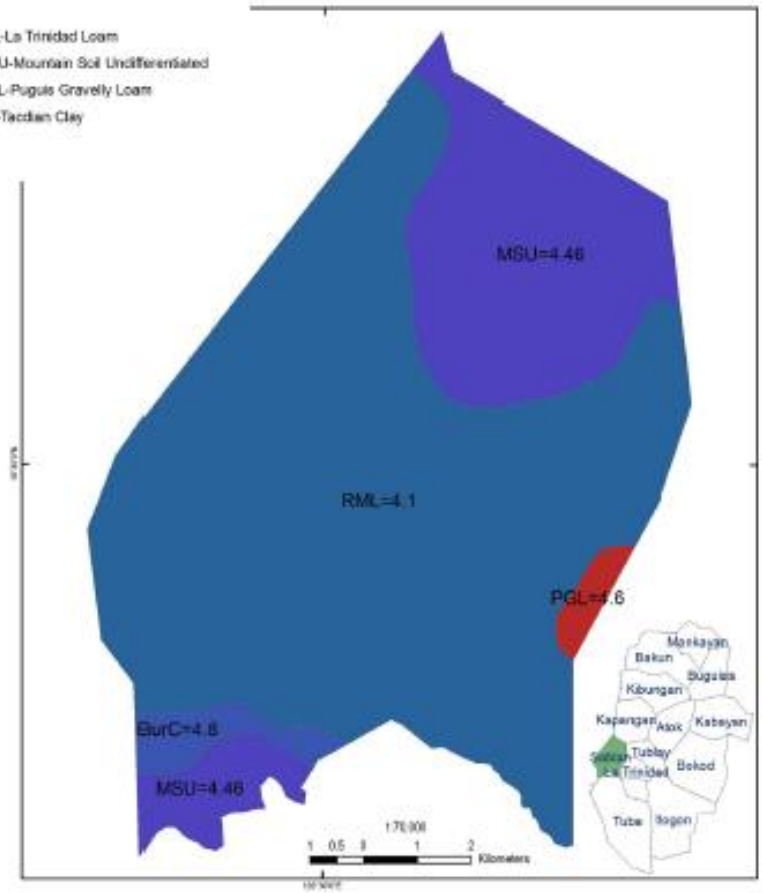
Municipal Boundary
DCL-Daclan Clay Loam
GL-Guinacang Loam
MSU-Mountain Soil Undifferentiated
NL-Natubleng Loam
RML-Rough Mountainous Land



SOIL pH
Municipality of La Trinidad
Province of Benguet

Legend

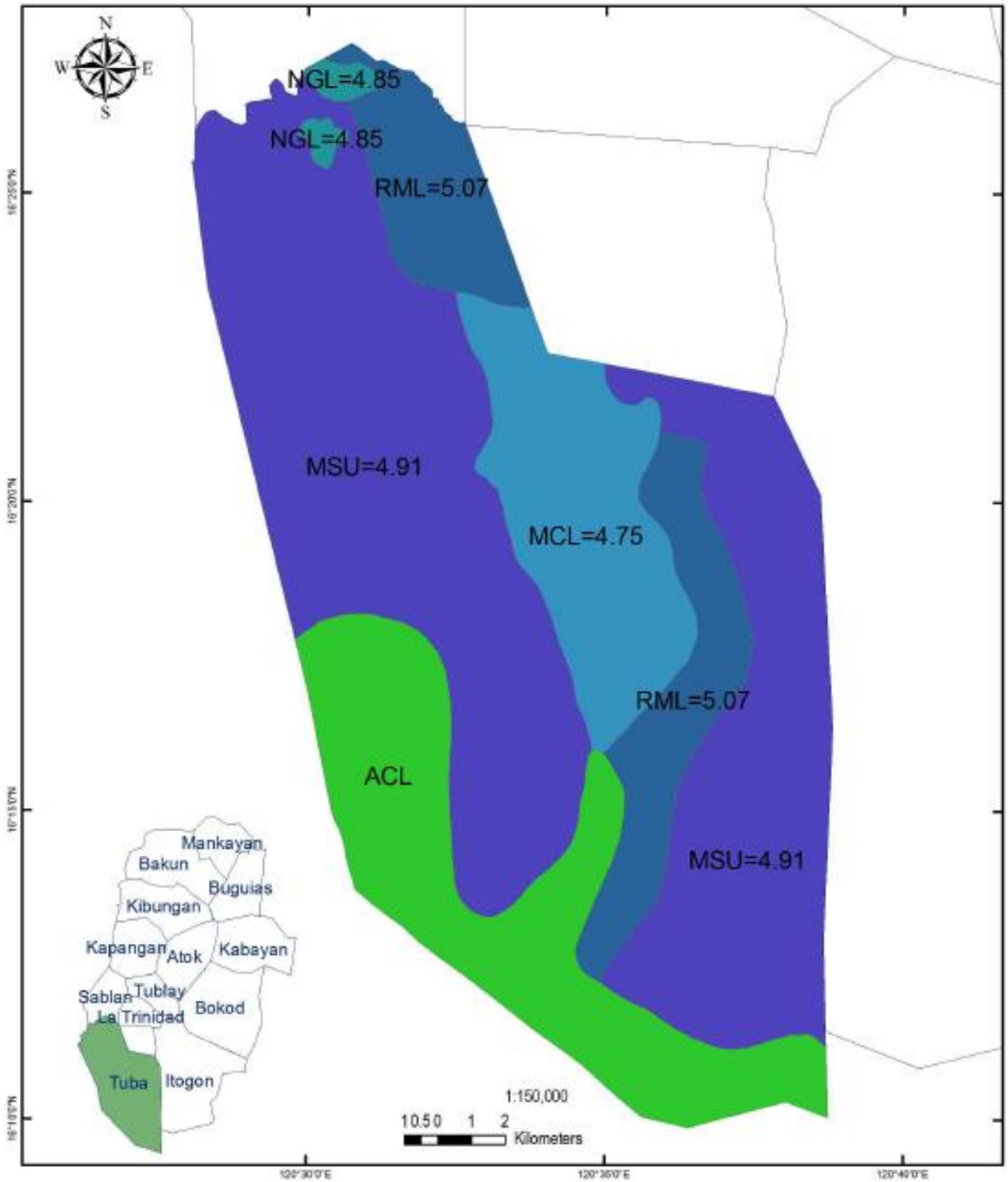
ASL-Ambassador Silt Loam
BCI-Bakakeng Clay
BISC-Bineng Sandy Clay
BuyCL-Buyagan Clay Loam
HCL-Halsema Clay Loam
LTL-La Trinidad Loam
MSU-Mountain Soil Undifferentiated
PGL-Pugulo Gravelly Loam
TC-Tacdian Clay



SOIL pH
Municipality of Sablan
Province of Benguet

Legend

BurC-Burgos Clay
MSU-Mountain Soil Undifferentiated
PGL-Pugulo Gravelly Loam
RML-Rough Mountainous Land



SOIL pH
Municipality of Tuba
Province of Benguet

Legend

- Municipal Boundary
- ACL- Annam Clay Loam
- MCL-Mirador Clay Loam
- MSU-Mountain Soil Undifferentiated
- NGL-Nangalisan Gravelly Loam
- RML-Rough Mountainous Land

Figure 1. Soil pH map of the major agricultural soils in the seven municipalities of Benguet

Table 3. Soil Organic Matter (%) status of the major agricultural soils in the seven municipalities of Benguet

Soil Type	Fertility Factor Per Municipality													
	Bokod	Fertility Status	Itogon	Fertility Status	Kabayan	Fertility Status	Kapangan	Fertility Status	La Trinidad	Fertility Status	Sablan	Fertility Status	Tuba	Fertility Status
Ambassador SiL	3.62	M	2.94	M					2.40	M				
Bakakeng C			2.63	M			0.90	U	2.16	M				
Balakbak Gr. L														
Bineng SC									1.94	U				
Burgos C											2.70	M		
Buyagan CL									3.58	M				
Daclan CL	2.62	M			3.11	M								
Guimbalaoan-Annam Complex	2.80	M												
Ginaoang L					2.31	M								
Halsema L									2.42	M				
La Trinidad L									2.10	M				
Mirador CL													2.73	M
Mountain Soil Undifferentiated	2.73	M	3.33	M	2.84	M	1.52	U	3.05	M	2.57	M	2.65	M
Nangalisan Gr. L													2.411	M
Natubleng L					3.02	M								
Puguis Gr. L							1.38	U	2.15	M	2.59	M		
Rough Mtn L							1.22	U			2.61	M	1.99	U
Tacdian CL									2.96	M				

Fertility rating of Soils (BSWM):

F–Favorable/Adequate: >4.5 % M - Moderately: 2.1-4.5 % U–Unfavorable/ Deficient: <2.0 %

Table 4. Phosphorus (ppm) status of the major agricultural soils in the seven municipalities of Benguet

Soil Type	Fertility Factor Per Municipality													
	Bokod	Fertility Status	Itogon	Fertility Status	Kabayan	Fertility Status	Kapangan	Fertility Status	La Trinidad	Fertility Status	Sablan	Fertility Status	Tuba	Fertility Status
Ambassador SiL	17.43	M	19.39	M					28.51					
Bakakeng C			17.31	M					19.12					
Balakbak Gr. L							7.01	U						
Bineng SC									35.02					
Burgos C											21.48			
Buyagan CL									27.15					
Daclan CL	17.86	M	23.28	M										
Guimbalaoan-Annam Complex	20.50	M												
Ginaoang L					25.00	M								
Halsema L									27.92					
La Trinidad L									0.11					
Mirador CL													9.11	
Mountain Soil Undifferentiated	15.30	M	19.50	M	19.80	M	7.71	U	23.01		14.46		18.82	
Nangalisan Gr. L													14.37	
Natubleng L					20.62	M								
Puguis Gr. L							17.70	U	25.53		25.46			
Rough Mtn L							20.18	U			22.78		17.37	
Tacdian CL									27.78					

Fertility rating of Soils (BSWM):

F– Favorable/Adequate: >30 ppm M - Moderately: 11.5-30 ppm U– Unfavorable/Deficient: <11 ppm

Table 5. Potassium (ppm) status of the major agricultural soils in the seven municipalities of Benguet

Soil Type	Fertility Factor Per Municipality													
	Bokod	Fertility Status	Itogon	Fertility Status	Kabayan	Fertility Status	Kapangan	Fertility Status	La Trinidad	Fertility Status	Sablan	Fertility Status	Tuba	Fertility Status
Ambassador SiL	130.25	M	117.10	M					28.51	U				
Bakakeng C			44.56	U			52.50	U	119.50	M				
Balakbak Gr. L														
Bineng SC									124.17	M				
Burgos C											95.00	U		
Buyagan CL									139.25	M				
Daclan CL	126.58	M			120.43									
Guimbalaoan-Annam Complex	109.88	M												
Ginaoang L					121.17	M								
Halsema L									114.33	M				
La Trinidad L									212.00	M				
Mirador CL													129.00	M
Mountain Soil Undifferentiated	94.89	U	19.50	U	95.00	U	65.17	U	91.01	U	99.39	U	117.89	M
Nangalisan Gr. L													125.50	M
Natubleng L					151.30	M								
Puguis Gr. L							109.10	M	132.83	M	65.00	U		
Rough Mtn L							49.02	U			128.36	M	85.12	U
Tacdian CL									162.53	M				

Fertility rating of Soils (BSWM):

F– Favorable/Adequate:>250ppm M - Moderately: 100-250 ppm U – Unfavorable/Deficient: <100 ppm

Table 6. Cation exchange capacity (ppm) status of the major agricultural soils in the seven municipalities of Benguet

Soil Type	Fertility Factor Per Municipality													
	Bokod	Fertility Status	Itogon	Fertility Status	Kabayan	Fertility Status	Kapangan	Fertility Status	La Trinidad	Fertility Status	Sablan	Fertility Status	Tuba	Fertility Status
Ambassador SiL	28.50	F	32.40	F					28.10	F				
Bakakeng C			24.51	F				F	31.76	F				
Balakbak Gr. L							31.37							
Bineng SC									40.40	F				
Burgos C											27.59	F		
Buyagan CL									59.74	F				
Daclan CL	38.52	F			38.52	F								
Guimbalaoan-Annam Complex	34.60	F												
Ginaoang L					39.30	F								
Halsema L									51.85	F				
La Trinidad L									55.15	F				
Mirador CL													46.39	F
Mountain Soil Undifferentiated	31.83	F	27.41	F	32.26	F	44.56	F	44.35	F	34.98	F	38.76	F
Nangalisan Gr. L													48.67	F
Natubleng L					41.41	F								
Puguis Gr. L							44.68	F	37.58	F	25.46	F		
Rough Mtn L							43.30	F			27.70	F	42.16	F
Tacdian CL									53.28	F				

Fertility rating of Soils (BSWM):

F – Favorable/Adequate: >20 me/100 g soil M - Moderately: 10-20 U – Unfavorable/Deficient: <10 me/100 g soil

Table 7. Cation Exchange Capacity (m.e./100 g soil) of the major agricultural soils in the seven municipalities of Benguet

Soil Type	Municipality						
	Bokod	Itogon	Kabayan	Kapangan	La Trinidad	Sablan	Tuba
Ambassador SiL	28.50	32.40			28.10		
Bakakeng C		24.51			31.76		
Balakbak Gr. L				31.37			
Bineng SC					40.40		
Burgos C						27.59	
Buyagan CL					59.74		
Daclan CL	38.52		38.52				
Guimbalaoan-Annam Complex	34.60						
Ginaoang L			39.30				
Halsema L					51.85		
La Trinidad L					55.15		
Mirador CL							46.39
Mountain Soil Undifferentiated	31.83	27.41	32.26	44.56	44.35	34.98	38.76
Nangalisan Gr. L							48.67
Natubleng L			41.41				
Puguis Gr. L				44.68	37.58	25.46	
Rough Mtn L				43.30		27.70	42.16
Tacdian CL					53.28		

Fertility rating of soils (BSWM):
Favorable: >20 me/100 g soil Moderately: 10-20 Unfavorable: <10

Exchangeable potassium

Potassium like nitrogen and phosphorus is a major plant nutrient. Potatoes are sensitive to potassium deficiencies.

Results show that agricultural soils of Bokod, Kabayan, La Trinidad and Tuba have moderate amounts of K (109.88 to 151.30 ppm) while soils of Itogon, Kapangan and Sablan are deficient (19.50 to 99.30 ppm) of the element (Table 5). The results imply the need to apply potassium containing fertilizers.

Cation Exchange Capacity (CEC)

The status of the agricultural soils in the seven municipalities of Benguet based on the cation exchange capacity (CEC) are adequate (Table 6) which indicates that most of the agricultural soils can hold adequate amounts of nutrients in the soils.

Soil Fertility Status and Fertilizer Recommendation for Major Crops

The fertilizer recommendations were prepared based on the results of soil analysis to come up with specific nutrient requirement which are the bases for computing the required amount to be recommended per specific crop per hectare basis. Table 8-14 shows the fertility status of the seven municipalities of Benguet based on the 20 cm depth from the surface layer as well as the recommended NPK and organic fertilizer of each crop being grown in each municipality.

Table 8. General fertility status and recommendation based on the weighted average of the soil fertility factors in Bokod

Soil type	Soil Fertility Factors				Crops	Fertilizer Recommendation (kg ha^{-1} or g/plt)			Organic Fertilizer (t ha^{-1})
	OM (%)	Available P	Exchangeable K (ppm)	CEC (me/100 g)		N	P	K	
Ambassador silt loam	3.62 **	21.43 **	130.25 **	28.50 ***	Beans	35	30	30	5
					Broccoli	70	40	30	5
					Cabbage	120	40	30	5
Daclan clay loam	2.62 **	17.86 **	126.58 **	38.52 ***	Beans	40	30	30	5
					Broccoli	80	40	30	5
					Cabbage	140	30	30	5
					Carrots	80	50	30	5
					Cauliflower	140	30	30	5
					Garden pea	40	40	30	5
					Onions	80	40	90	5
					Rice (wet)	60	0	0	5
					Rice (dry)	80	0	0	5
					Tomato	80	60	30	5
Guimbalaon-Annam complex	2.80 **	20.50 **	109.88 **	34.60 ***	Beans	40	30	45	5
					Cabbage	140	20	60	5
					Celery	50	40	45	5
					Garden pea	40	40	60	5
					Onions	80	40	90	5
					Pepper	80	40	60	5
					Tomato	80	60	60	5
Mountain soil undifferentiated	2.73 **	15.30 **	94.89 **	31.83 ***	Beans	40	40	45	5
					Broccoli	80	60	45	5
					Cauliflower	140	30	45	5
					Corn	40	30	45	5
					Cucumber	40	50	30	5
					Onions	80	40	120	5
					Pepper	80	60	60	5
					Petchay	140	40	75	5
					Rice (wet)	60	20	60	5
					Rice (dry)	80	20	60	5
					Tomatoes	80	90	60	5

Legend: * deficient ** moderate *** adequate

Table 9. General fertility status and recommendation based on the weighted average of the soil fertility factors in Itogon

Soil type	Soil Fertility Factors				Crops	Fertilizer Recommendation (kg ha^{-1} or g/plt)			Organic Fertilizer (t ha^{-1})
	OM (%)	Available P	Exchangeable K (ppm)	CEC (me/100 g)		N	P	K	
Ambassador silt loam	2.94 **	19.39 **	117.10 **	32.40 ***	Beans	35	30	30	5
					Broccoli	70	40	30	5
					Carrots	120	40	30	5
					Celery				
					Chayote				
					Cucumber				
					Garden pea	40	30	30	5
					Mums (cutflowers)	(kg/plant/week)			
					Non-flowering	140	30	30	5
					Flowering	80	50	30	5
					Pepper	140	30	30	5
					Petchay	40	40	30	5
					Tomato	80	40	90	5
Bakakeng Clay	2.63 **	17.31 **	44.56 **	24.51 ***	Beans	40	30	60	5
					Bell pepper	80	30	75	5
					Camote	50	30	90	5
					Mums	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering (kg/plant/week)	0.3	0.4	0	5
					Citrus	kg/plant			
					New	.010	.005	.015	5
					1st year	.020	.008	.030	5
					2nd year	.030	.010	.060	5
					3rd year	.040	.015	.090	5
					4th year	.060	.020	.015	5
					5th year	.100	.030	.030	5
					6-10	.200	.050	.450	5
					11-15	.300	.100	.600	5
					Over 15 years	.400	.200	.750	5
					New	.002	.001	.003	5
					1st year	.025	.010	.045	5
					2nd year	.035	.020	.048	5
					3rd year	.040	.025	.060	5
					4th year	.050	.025	.075	5
					5th year	.070	.030	.090	5
					6-10	.100	.020	.360	5
					11-15	.145	.025	.450	5
					Over 15 years	.100	.020	.300	5
					Tomato	80	60	90	5
Mountain soil undifferentiated	2.73 **	15.30 **	94.89 **	31.83 ***	Beans	40	30	60	5
					Corn	70	30	60	5
					Pepper	80	40	75	5
					Rice (wet)	60	0	60	5
					Rice (dry)	80	0	60	5

Legend: * deficient **moderate *** adequate

Table 10. General fertility status and recommendation based on the weighted average of the soil fertility factors in Kabayan

Soil type	Soil Fertility Factors				Crops	Fertilizer Recommendation (kg ha^{-1} or g/plt)			Organic Fertilizer (t ha^{-1})
	OM (%)	Available P	Exchangeable K (ppm)	CEC (me/100 g)		N	P	K	
Daclan clay loam	3.11 **	23.28 **	120.43 **	38.52 ***	Beans	40	20	30	5
					Broccoli	80	20	30	5
					Cabbage	140	20	30	5
					Carrots	80	30	30	5
					Cauliflower	140	20	30	5
					Onions	80	20	90	5
					Pepper	80	20	30	5
					Rice (wet)	60	0	0	5
					Rice (dry)	80	0	0	5
					Tomato	80	30	30	5
Ginaoang loam	2.31 **	25.00 **	12.17 **	39.30 ***	Broccoli	80	20	30	5
					Cabbage	140	20	30	5
					Carrot	80	30	30	5
					Cauliflower	140	20	30	5
					Onions	80	20	90	5
					Tomato	80	30	30	5
Mountain soil undifferentiated	2.84 **	19.80 **	95.00 **	35.26 ***	Cabbage	140	30	60	5
					Carrot	80	30	30	5
					Cauliflower	140	30	45	5
					Garden pea	40	40	30	5
					Tomato	80	60	60	5
Natubleng loam	3.02 **	20.62 **	151.30 **	41.41 ***	Beans	40	30	0	5
					Broccoli	80	40	0	5
					Cabbage	140	30	0	5
					Carrot	80	50	0	5
					Cauliflower	140	30	0	5
					Garden pea	40	40	0	5
					Pepper	80	40	0	5
					Potatoes	80	30	0	5
					Tomato	80	60	0	5

Legend: * deficient ** moderate ***adequate

Table 11. General fertility status and recommendation based on the weighted average of the soil fertility factors in Kapangan

Soil type	Soil Fertility Factors				Crops	Fertilizer Recommendation (kg ha^{-1} or g/plt)			Organic Fertilizer (t ha^{-1})
	OM (%)	Available P (ppm)	Exchangeable K (ppm)	CEC (me/100 g)		N	P	K	
Balakbak Gravelly Clay Loam	0.90 *	7.0 *	52.50 *	31.37 ***	Beans	50	60	60	5
					Camote	60	60	90	5
					Rice (wet)	80	30	45	5
					Rice (dry)	100	30	45	5
Mountain Soil Undifferentiated	1.52 *	7.71 *	65.17 *	44.65 ***	Corn	90	60	60	5
					Beans	50	60	60	5
					Cucumber	60	60	60	5
					Pepper	90	80	150	5
					Rice (wet)	80	30	30	5
					Rice (dry)	100	30	30	5
Puguis Gravelly Loam	1.38 *	17.70 **	109.00 **	44.68 ***	Beans	50	30	45	5
					Cucumber	60	30	30	5
					Eggplant	90	40	60	5
					Onions	150	40	120	5
					Pepper	90	40	75	5
					Rice (wet)	80	0	0	5
					Rice (dry)	100	0	0	5
					Tomato	90	60	60	5
Rough Mountainous Land	1.22 *	20.18 **	49.02 *	43.30 ***	Beans	50	30	60	5
					Broccoli	90	40	60	5
					Cabbage	150	30	60	5
					Corn	90	30	60	5
					Cucumber	60	50	45	5
					Peanuts	30	20	45	5
					Pepper	90	40	150	5
					Rice (wet)	80	0	30	5
					Rice (dry)	100	0	30	5
					Sweet Potato	60	30	90	5

Legend: * deficient ** moderate ***adequate

Table 12. General fertility status and recommendation based on the weighted average of the soil fertility factors in La Trinidad

Soil type	Soil Fertility Factors				Crops	Fertilizer Recommendation (kg ha^{-1} or g/plt)			Organic Fertilizer (t ha^{-1})
	OM (%)	Available P (ppm)	Exchangeable K (ppm)	CEC (me/100 g)		N	P	K	
Ambassador Silt Loam	2.40 *	28.51 *	28.51 *	28.10 ***	Celery	50	20	60	5
					Chenkang	140	0	75	5
					Lettuce	40	20	75	5
					Romaine	40	20	75	5
					Spinach	140	20	75	
Bakakeng Clay	2.16 *	19.12 *	119.50 *	31.76 ***	Broccoli	80	40	30	5
					Cabbage	140	30	30	5
					Cauliflower	140	30	30	5
					Chinese Cabbage	140	30	30	5
Bineng Sandy Clay	1.94 *	35.02 **	124.17 **	40.40 ***	Anthurium	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Beans	50	0	30	5
					Broccoli	90	0	30	5
					Cauliflower	150	0	30	5
					Chayote	60	0	30	5
					Gabi	90	0	30	5
					Onions	150	0	90	5
Buyagan Clay Loam	3.58 **	27.51 **	139.25 **	59.74 ***	Cabbage	140	20	30	
					Lettuce	40	20	30	5
					Onions	70	20	90	5
					Strawberry	2g/ plant	0g/ plant	1g/ plant	5
Halsema Loam	2.42 **	27.92 **	114.33 **	51.85 ***	Aster	(kg/plant/week)			
					Non-fowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Broccoli	80	20	30	5
					Chayote	50	20	30	5
					Chengkang	140	0	30	5
					Cut flowers	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Lettuce	50	20	30	5
					Mums	(kg/plant/week)			
					Non-Flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Petchay	140	20	30	5

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La Trinidad Loam	2.10 **	0.11 *	212.00 **	55.15 ***	Chinese Cabbage	140	60	0	5
					Lettuce	50	60	0	5
					Onions	80	80	0	5
					Petchay	140	40	0	5
					Strawberry	2g/plant	0g/plant	1g/plant	5
Mountain Soil Undifferentiated	3.05 **	23.01 **	91.01 *	44.35 ***	Beans	40	20	45	5
					Broccoli	80	20	45	5
					Cabbage	140	20	60	5
					Lettuce	50	20	60	5
					Onions	80	20	120	5
					Pepper	140	20	60	5
					Petchay	140	20	60	5
					Plastic Pepper	140	20	60	5
					Spinach	140	20	60	5
					Tomatoes	80	30	60	5
Puguis Gravelly Loam	2.15 **	25.53 **	132.83 **	37.58 ***	Beans	40	20	30	5
					Broccoli	80	20	30	5
					Celery	50	20	30	5
					Mums	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Onions	80	20	90	5
					Petchay	140	20	30	5
					Rose	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0.0	5
					Strawberry	2g/plant	0g/plant	1g/plant	5
Tacdian Clay	2.96 **	27.78 **	162.50 **	53.28 ***	Aster	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Broccoli	80	20	0	5
					Cauliflower	140	20	0	5

Legend: *deficient ** moderate *** adequate

Table 13. General Fertility status and recommendation based on the weighted average of the soil fertility factors in Sablan

Soil type	Soil Fertility Factors				Crops	Fertilizer Recommendation (kg ha^{-1} or g/plt)			Organic Fertilizer (t ha^{-1})
	OM (%)	Available P (ppm)	Exchangeable K (ppm)	CEC (me/100 g)		N	P	K	
Burgos Clay	2.70 *	21.48 **	95.00 *	27.59 ***	Rice (wet)	60	0	7	5
					Rice (dry)	80	0	7	5
Mountain Soil Undifferentiated	2.57 **	14.46 **	99.39 *	34.98 ***	Beans	40	40	45	5
					Broccoli	80	60	45	5
					Chayote	50	60	45	5
					Cucumber	40	50	30	5
					Garden pea	40	30	30	5
					Pepper	60	60	120	5
					Rice (wet)	60	20	7	5
					Rice (dry)	80	20	7	5
					Tomato	80	90	60	5
Puguis Gravelly Loam					Chayote	50	20	60	5
Rough Mountain Land					Anthurium	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Banana	.1kg/ tree	0kg/ tree	0.05kg/ tree	5
					Beans	40	30	30	5
					Broccoli	80	40	30	5
					Cabbage	140	30	30	5
					Chayote	50	40	30	5
					Mums	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Coffee	(kg/plant)			
					New	.002	0	.001	5
					1st year	.025	0	.012	5
					2nd year	.035	0	.018	5
					3rd year	.040	0	.270	5
					4th year	.050	0	.030	5
					5th year	.070	0	.045	5
					6-10	.100	0	0.06	5
					11-15	.145	0	.090	5
					Over 15 years	.100	0	.050	5

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Cucumber	40	50	30	5
Garden pea	40	20	30	5
Pepper	60	40	90	5
Petchay	140	30	30	5
Pineapple	200	0	60	5
Rice (wet)	60	0	0	5
Dry (dry)	80	0	0	5
Sweet Potato	50	30	30	5
Tomato	80	60	30	5

Legend: * deficient ** moderate *** adequate

Table 14. General fertility status and recommendation based on the weighted average of the soil fertility factors in Tuba

Soil type	Soil Fertility Factors				Crops	Fertilizer Recommendation (kg ha^{-1} or g/plt)			Organic Fertilizer (t ha^{-1})
	OM (%)	Available P	Exchangeable K (ppm)	CEC (me/100 g)		N	P	K	
Mirador Clay Loam	2.73 **	9.11 *	129.00 **	46.39 ***	Cabbage	140	60	30	5
					Carrot	80	90	30	5
					Potato	80	60	30	5
Mountain soil undifferentiated	2.65 **	18.82 **	117.89 **	38.76 ***	Banana	.1kg/ tree	.035kg/ tree	.05kg/ tree	5
					Beans	40	30	30	5
					Bell Pepper	60	40	90	5
					Broccoli	80	40	30	5
					Cabbage	140	30	30	5
					Carrot	80	50	30	5
					Chinese Cabbage	140	30	30	5
					Corn	70	30	30	5
					Cucumber	40	50	30	5
					Garden pea	40	40	30	5
					Mums	(kg/plant/week)			
					Non-flowering	0.2	0.2	0.3	5
					Flowering	0.3	0.4	0	5
					Pepper	80	30	30	5
					Pineapple	200	20	60	5
					Potato	80	30	30	5
					Rice (wet)	60	0	0	5
					Rice (dry)	80	0	0	5
					String beans	40	30	30	5
					Ube	50	30	30	5

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Nangalisan Gravelly Loam	2.41 **	14.37 *	125.50 **	48.67 ***	Banana	.1kg/ tree	.07kg/tree	.05kg/ tree	5
					Gabi	50	30	90	5
					Rice (wet)	60	20	0	5
					Rice (dry)	80	20	0	5
					Sweet Potato	50	40	30	5
Rough Mountainous Land	1.99 *	17.37 **	85.21 *	42.16 ***		50	30	45	5
						90	30	45	5
						60	50	30	5
						150	30	60	5
						80	0	7	5
						100	0	7	5
						90	60	60	5

Legend: * deficient **moderate ***adequate

CONCLUSIONS AND RECOMMENDATIONS

Most of the agricultural soils in the seven municipalities have pH values of 4.2 to 4.9 indicating a strongly acidic soil which is unfavorable for crop production. Only the soils of Bokod, Itogon and Kapangan are moderately favorable to favorable with pH ranging from 5.0 to 6.5 although some areas have pH values below 5.0.

Agricultural soils in the municipalities of Bokod, Itogon, Kabayan, La Trinidad, Sablan and Tuba have moderate amounts of OM which range from 2.16 to 3.58 %. Only agricultural soils in Kapangan have deficient OM.

Agricultural soils of Kapangan are deficient of P (7.01 to 7.71 ppm) while the soils of the other six municipalities have moderate amount (14.46 to 28.5 ppm) of the element.

Agricultural soils of Bokod, Kabayan, La Trinidad and Tuba have K contents ranging from 109.88 to 151.30 ppm which is considered moderate while soils of Itogon, Kapangan and Sablan are deficient (19.50 to 99.39 ppm).

The CEC of all the agricultural soils in the seven municipalities range from 25.46 to 59.74 m.e./100 g soil which is favorable for crop production.

Based on the findings, majority of the agricultural soils in Kabayan, La Trinidad, Sablan and Tuba except Bokod, Itogon and Kapangan are strongly acidic.

Agricultural soils of Bokod, Itogon, Kabayan, La Trinidad, Sablan and Tuba except Kapangan have moderate amounts of OM and P.

Agricultural soils of Bokod, Kabayan, La Trinidad and Tuba have moderate amounts of K while soils of the other municipalities are deficient of the soil nutrient.

For areas that are very strongly, and strongly acidic, lime application based on recommended rate should be applied to increase the soil pH in accordance to the pH requirement of crops.

Organic matter of the soil should be maintained by applying organic fertilizer at the rate of 5 tons per hectare.

For phosphorus and potassium-deficient areas, addition of readily soluble P and K containing materials and compost to increase the amount of the elements is recommended.

The fertilizer recommendations for the various crops being grown in the seven municipalities are important as guide for the specific rates of fertilizer to be applied in the specified crops grown in each municipality.

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