Soil Chemical Characteristics and Fertility Status in Dryland Areas: A Case Study of Karieng Village, Grong Grong District, Pidie Aceh Regency

Sri Handayani[1], Budi Alhadi[2*], Cut Mulia Sari[3], Erayani Erayani[4]

[1] *Agrotechnology Department, Universitas Jabal Ghafur, Aceh, Indonesia*
[2] *Agrotechnology Department, Universitas Jabal Ghafur, Aceh, Indonesia*
[3] *Agrotechnology Department, Universitas Jabal Ghafur, Aceh, Indonesia*
[4] *Agrotechnology Department, Universitas Jabal Ghafur, Aceh, Indonesia*
Email: budi.alhadi@gmail.com

ABSTRACT

The sustainable development and management of arid regions in Indonesia are imperative, given the diminishing land area available for cultivation. A crucial aspect of this management involves assessing the soil fertility status to understand the extent of soil productivity. This study focused on Karieng Village, situated in the Grong Grong District of Pidie Aceh Regency. Employing a descriptive-quantitative approach, the methodology utilized various parameters to evaluate soil fertility status, including soil pH, cation exchange capacity, alkaline saturation (KB), total P2O5, K2O, and C-Organic. The results revealed that Cation Exchange Capacity (CEC) and Base Saturation (KB) levels were high and very high, respectively. Conversely, phosphorus (P) exhibited very low to low values, while potassium (K) demonstrated low, medium, and very high criteria. Additionally, C-Organic criteria ranged from very low to low. Overall, the assessment categorized the soil fertility status in the research area as moderate. The primary limiting factors identified were low levels of organic carbon and phosphorus content in the soil. This information is crucial for devising targeted strategies to enhance soil fertility and promote sustainable agricultural practices in the region.

Keywords: *Dryland, Soil chemistry, Soil fertility.*

1. INTRODUCTION

Indonesia currently lacks productive land. This is due to land use change that does not consider the potential of the land. Lessproductive dry lands have also been managed. Dryland itself is a stretch of land that is never inundated or waterlogged at most times of the year. This dry land is included in the sub-optimal land group. We know that sub- optimal land or marginal lands are problematic land, especially the level of fertility. Most of these sub-optimal lands have low soil fertility levels so that for managementthey face many obstacles.

Nevertheless, the escalating human needs, particularly with regard to food, have led to the continued cultivation of these lands without due consideration for the processes of nutrient addition or depletion. This if done continuously will result in a decrease in the quality of the soil itself, so before management actions are carried out, it should be necessary to evaluate the status of soil fertility to minimize land degradation.

The research is situated in Karieng Village, Grong Grong District, Pidie Aceh Regency, encompassing an approximately 300 Ha area characterized by less fertile land, with only 30% currently under cultivation. The remaining 70% has remained untouched by the local community due to the presence of lime in the soil. Notably, there is a lack of data and information regarding the soil fertility potential in this area. Consequently, it becomes imperative to conduct research to assess the potential of soil fertility on this dry land. The anticipated outcome of this research is the acquisition of accurate data and information concerning the soil's fertility potential. Subsequently, the management actions implemented will align with the insights derived from the research results. This strategic approach aims to ensure that management efforts are precisely targeted, thereby enhancing regional food productivity.

The potential fertility of the soil of a land needs to be known so that there are no problems in its management. Soil fertility potential depends on the soil's physical properties, soil chemical properties and soil biology. Expert opinion [2] Soil and crop productivity is largely determined by the level of

B. I. Ansari and M. Sagita (eds.), *Proceedings of the International Conference on Educational Technology and Social Science (ICoETS 2023)*, Advances in Social Science, Education and Humanities Research 820,
https://doi.org/10.2991/978-2-38476-200-2_15

soil fertility, so fertilization as an effort to add nutrients to the soil is important so that agricultural production increases every year.

Research Objectives

To evaluate the potential of soil fertility on dry land in Karieng Village, Grong- Grong District.

Research Benefits

Obtain data and information on the status of macronutrients, soil pH, soil CEC and soil KB in dry land in Karieng Village, Grong- Grong District.

As a management recommendation to improve soil fertility in Karieng Village, Grong-Grong District, to determine the location of the SPL point using GPS. Then there are all SPL points will be observed morphological and chemical properties of the soil.

The determination of SPL points is made by compiling several maps above each other *(overlay*), namely soil type maps, altitude maps and land use maps (Appendices 3, 4 and 5). So the SPL map (Appendix 6) and sampling point map (Appendix 7) will be obtained to observe and take soil samples. Observations of the nature and type of land for all SPL points were directly carried out at the study site. Soil samples are taken in the topsoil (0-20 cm) and subsoil (20-40 cm) soil layers which are then observed and analyzed in the laboratory for soil chemical properties.

2. RESEARCH METHODOLOGY

This research has been conducted inKarieng Village, Grong Grong District. Sample measurements were carried out at the Soil andPlant Research laboratory, Faculty of Agriculture USK, from February to May 2021

For field observations the following materials: solutions of hydrogen peroxide, aquades, and hydrochloric acid as well as several kinds of maps, namely soil type maps, land use maps, altitude maps, andadministrative maps. The tools used are Global Positioning System (GPS), plastic sacks, straps, ring samples, abney levels, soil description fill sheets, *Munsel soil color chart* books, hoe, scopes, soil drills, knives, meters, pens, pencils, erasers, cameras and other tools.

The method used is descriptive- quantitative (measurable) by making observations at the location, then a land map unit (SPL) is determined to be observed soil samples are taken and analysis is carried out in the laboratory.

To support the completeness of data in the field, supporting data were collected from government offices, namely climate data, maps and the state of the research location area.

Pre-Survey and Survey

Research activities begin by determining observation points, which are drilled at different slopes, and then determining SPL points to be studied. Coordinate point retrieval

Research Benefits

Obtain data and information on the status of macronutrients, soil pH, soil CEC and soil KB in dry land in Karieng Village, Grong- Grong District.

As a management recommendation toimprove soil fertility in Karieng Village, Grong-Grong District to determine the location of the SPL point using GPS. Then there are all SPL pointswill be observed morphological and chemical properties of the soil.

The determination of SPL points is made by compiling several maps above each other *(overlay*), namely soil type maps, altitudemaps and land use maps (Appendices 3, 4 and 5). So the SPL map (Appendix 6) and sampling point map (Appendix 7) will be obtained to observe and take soil samples. Observations of the nature and type of land

for all SPL points were directly carried out at the study site. Soil samples are taken in the topsoil (0-20 cm) and subsoil (20-40 cm) soil layers which are then observed and analysed in the laboratory for soil chemical properties.

Field Observations

The soil samples taken are at each point onthe land map unit consisting of 6 SPL. The soil samples taken consisted of 6 total samples taken from 6 SPLs. One of the SPLs will be carried out profile excavation for soil profile observation. The soil samples were then measured at the Soil and Plant Research Laboratory, Faculty of Agriculture, USK. The observed parameters can be seen in Table 1.

Table 1. Chemical Properties Analysis parameters

Number	Parameters	Analysis Methods
1.	pH H2O, pH KCl	Electrometer
2.	C-organic content	Walkley &; Black
3.	Phosphate-available	Bray II
4.	Potassium, Sodium, Magnesium,Calcium	1N NH4OAc pH 7.0
5.	Al-dd and H-dd	1 N KCl
6.	KB	$KB = \frac{\sum basa - basa\ dd}{KTK} x\ 100\%$
7.	CEC	1N NH4OAc pH 7.0

After obtaining the measurement results in the laboratory, it is adjusted to the standard table of soil fertility assessment, to determine the level of soil fertility at the research site. The criteria for soil chemical fertility are presented in Appendix 13.

3. RESULTS AND DISCUSSION

Soil Chemical Characteristics

Data on soil chemical properties were analyzed in the laboratory at each SPL (land map unit) and the results of the assessment criteria are listedin Table 2.

		C-Organic (%)	N-total (%)	C/N	P Bray II (mg kg)	Ca-dd (cmol kg-1)	Mg-dd (cmol kg-1)	K-dd (cmol kg-1)	Na-dd (cmol kg-1)	CEC (cmol kg-1)	KB (%)	Al-dd (cmol kg-1)	DHL (mS cm-1)	pH (H2O)	pH (KCL)
SPL 1	Top	1,85 R	0,17 R	10,88 R	3,65 SR	22,17 ST	0,56 R	0,35 S	0,06 SR	42,00 ST	55,01 T	Tu	0,35 SR	7,61 Aa	6,40 Aa
	Sub	1,40 R	0,15 R	9,33 R	4,65 SR	28,04 ST	0,59 R	0,28 R	0,05 SR	39,60 T	73,13 ST	Tu	0,70 SR	7,28 N	6,89 Aa
SPL 2	Top	1,69 R	0,18 R	9,38 R	6,00 SR	29,03 ST	0,62 R	0,53 S	0,06 SR	39,20 T	77,14 ST	Tu	0,25 SR	7,45 N	5,21 N
	Sub	0,48 SR	0,10 R	4,8 SR	6,90 SR	32,49 ST	0,63 R	0,25 R	0,06 SR	36,80 T	90,84 ST	Tu	0,25 SR	7,07 N	6,74 A
SPL 3	Top	1,66 R	0,15 R	0,11 R	10,60 R	36,98 ST	0,57 R	0,30 R	0,05 SR	39,00 T	97,18 ST	Tu	0,25 SR	7,21 N	6,96 A
	Sub	0,84 SR	0,08 SR	10,5 R	10,90 R	32,24 ST	0,57 R	0,21 R	0,06 SR	38,00 T	87,05 ST	Tu	0,35 SR	7,45 N	6,84 A
SPL 4	Top	1,30 R	0,13 R	10 R	2,40 SR	39,82 ST	0,57 R	0,13 R	0,06 SR	40,80 ST	99,46 ST	Tu	0,23 SR	7,93 Aa	6,96 A
	Sub	0,82 SR	0,09 SR	9,11 R	0,50 SR	36,06 ST	0,53 R	1,06 ST	0,06 SR	38,40 T	98,20 ST	Tu	0,20 SR	7,97 Aa	6,85 A
SPL 5	Top	1,18 R	0,13 R	9,07 R	2,50 SR	25,21 ST	0,54 R	2,35 ST	0,06 SR	39,20 T	71,84 ST	Tu	0,20 SR	6,19 Am	5,92 N
	Sub	0,97 SR	0,12 R	8,08 R	1,50 SR	22,74 ST	0,61 R	1,70 ST	0,05 SR	36,80 T	68,21 T	Tu	0,15 SR	6,29 Am	5,86 N
SPL 6	Top	1,37 R	0,13 R	1,43 R	6,00 SR	24,30 ST	0,55 R	6,89 ST	0,06 SR	33,20 T	95,78 ST	Tu	0,20 SR	6,92 N	5,67 N
	Sub	0,92 SR	0,12 R	0,52 R	3,70 SR	19,42 ST	0,61 R	6,30 ST	0,04 SR	30,00 T	87,90 ST	Tu	0,10 SR	6,68 N	5,21 N

Source: Unsyiah Soil and Plant Research Laboratory (2021)
Note: Very Low(SR), Low(R), Medium(S), High(T), High(T), High(ST), Unmeasured (tu), Mildly Sour(AM), Neutral(N), Mildly Alkaline(Aa), Alkalis(A)

C- Organic

The C-organic content is low in each SPL in the topsoil layer, while the subsoil layeris also low in SPL 1 while SPL 2,3,4,5, 6 is very low. The top soil layer always gets a continuous intake of organic matter. The organic matter content of the subsoil layer due to soil processing, transportation by soil organisms and leaching of organic matter [2].

N-total

All SPLs at the study site had low N- total levels in the topsoil layer. The total N value for the subsoil layer at SPL 3, 4, 5 and 6 is very low and at SPL 1 and 2 is low. From the results of the study [1,3] The process of leaching nutrients will cause a nutrient loss in the soil so that the N nutrient element tends to decrease with the deeper the soil layer. Loss of nutrient N in the soil consists of loss in the form of gas, loss due to leaching and transport during harvest.

P- available

P content is available at the study site in the topsoil layer and very low criteria in SPL 1, 2, 4, 5, 6 and low criteria in SPL 3. The low availability of P is due to binding by the content of C-organic in the soil because P is not absorbed. Expert opinion states [4] P nutrient content is influenced by pH and Aluminium in the soil. Nutrient P is dynamic so that some phosphor is not available in acidic soils.

Cation Exchange Capacity (CEC)

The CEC content in the topsoil layer has very high criteria in SPL 1 and 4 and high criteria in SPL 2, 3, 5 and 6. For the subsoil layer with high criteria on each SPL. The high value of CEC in the study land is caused by the washing process too often occurs in the soil where this is also supported by a neutral pH value. Soils with high CEC values tend to be more fertile because they have nutrient reserves [5].

Base Saturation (KB)

At SPL 2, 3,4 and 6 k valuesalkaline saturation of layers topsoil and high criteria subsoil while SPL 1 has high criteria inthe top soil layer and for SPL 5 has high criteria in the subsoil layer. High alkaline saturation value in the field [6] showing that basic cations dominate the exchange complex, the absorption of cations that are present at once quite effectively can affect neutral and stable pH values.

Soil pH

At SPL 2,3,5 and 6, the pH of the topsoil layer is neutral. As for SPL 1 and 4, the pH value has a somewhat alkaline criterion. For SPL 1, 2, 3 and 6, the pH of the subsoil layer is neutral, SPL 4 is slightly alkaline while SPL 5 is slightly acidic. High linear pH value with high soil CEC value in the study land. Soil reaction is the degree of acidity or alkalinity of the soil, where whether or not the nutrient element is easily absorbed by plants is influenced by the degree of soil acidity. Conditions at neutral soil pH, nutrients are easy and can be absorbed well [7].

Ca- dd

All SPL research locations have very high Ca-dd content in topsoil and subsoil layers. In general, Ca-dd values at the study site showed very high in topsoil and subsoil. Soil science experts state [9] The amount of Cadd that can be exchanged in the soil is related to the size of the soil CEC. The higher the CEC value of the soil, the higher the amount of Ca in the soil. Leaching can cause alkaline cations to decrease in the soil, in addition to being absorbed and transported during harvest, plusno fertilization or liming is done to restore theelement [9]

Mg-dd

The levels of magnesium- interchangeable nutrients in each SPL are low in both the topsoil and subsoil layers. Results of previous research [10] that the availability of Mg will decrease if there is an increase in the pH value of the soil past neutral. And the average soil pH value at the study site was neutral and alkaline.

K-dd

The topmostland in Land Map Units (SPL) 1 and 2 has medium criteria while in Land Map Units (SPL) 3 and 4 has low criteria. And at SPL 5 and 6 the criteria are very high. While the content of K-dd in the subsoil layer at SPL 1, 2 and 3 is low. And very high at SPL 4.5 and 6. This is because the availability of potassium in the soil is also determined by the type of parent material and soil pH. Where the availability of Potassium will decrease if the pH of the soil is acidic

Electrical Conductivity (DHL)

Each SPL at the study site**,** DHL rate the topsoil and subsoil layers are very low. This is because sodium levels at the study site are low. Expert opinion states [11] Colloidal [7].

Na-dd

Na-interchangeable content in the topsoil and subsoil layers is criterial low at each SPL. Results of previous research [13] thatlow K and Na cations in the soil will directly affect the content Na-dd, where leaching and percolation will bring these cations to be released into the soil horizon.

Al-dd

The results of Table 2 analysis show that Aluminium-interchangeable values for all SPLs are not measurable in both the topsoil and subsoil layers. Aluminium complexes formed by organic acids are one-way plants tolerate Aluminium. Organic acids play a role in detoxifying Aluminium by chelate Al and reduce or inhibit the effects of Aluminium toxicity [14] and the ability of the solution to conduct electricity will increase [11].

Soil Fertility Evaluation

Data from several parameters of soil chemical properties were then matched with soil fertility criteria tables to determine soil fertility status in Karieng Village, Grong grong district. Soil can conduct electricity quickly if sodium levels increase. Electrical Conductivity (DHL) is an indicator of salt concentration levels in the soil to monitor nutrient solution concentrations [12]. Aspects that are a reference for assessing soil fertility status, namely C-Organic, P_{2O5}, K2O, CEC and KB. Soil chemical properties and soil fertility criteria are listed in Table Assessment And Soil Fertility Status aims to know the level of soil fertility, nutrientavailability, so that fertilization recommendations can be determined. The determination of soil fertility evaluation only

Table 3. Chemical properties and soil fertility criteria at the research location of each SPL

SPL	CEC (cmol/kg)	KB (%)	P2O5 (mg/ kg)	K2O (cmol/kg)	C-Organic (%)	Fertility status
1	40,8 (St)	64,11 (T)	4,15 (Sr)	0,31 (R)	1,62 (R)	Keep
2	38 (T)	83,99 (St)	6,45 (Sr)	0,39 (R)	1,08 (R)	Keep
3	38,5 (T)	92,11 (St)	10,75 (R)	0,25 (R)	1,25 (R)	Keep
4	39,6 (T)	98,83 (St)	1,45 (Sr)	0.59 (S)	1,06 (R)	Keep
5	38 (T)	70,02 (St)	2 (Sr)	2,02 (ST)	1,07 (R)	Keep
6	31,6 (T)	91,84 (St)	4,85 (Sr)	6,59 (ST)	1,14 (R)	Keep

Description:Very High (St), High (T), Medium (S), Low (R), Very Low (Sr).

After obtaining measurement results from the laboratory, then proceed with matching for soil fertility criteria [16], then it can be determined that the fertility status of the study location is for all SPL (SPL 1 – SPL 6)is medium with limiting factors for SPL 1, 2 and 3 namely phosphorus, potassium and C organic content. While the limiting factors in SPL 4, 5 and 6 are C-organic and phosphorus.C-organic levels that tend to be low in the study area will affect the P value in the soil.

Availability of P in the soil [16] Also influenced by the content of organic matter. Source Phosphor is from the weathering of minerals containing P for example apatite minerals, and weathering of organic matter Low C-organic in the study site is suspected that dry land in the study area is often processed without the addition of organic materials, return of unused crops, for example straw and litter. And when cultivating the land, farmers are also lazy to fertilize, especially organic fertilizers.

Low P, K and C-organics in SPL 1, 2 and 3 need to be managed by fertilizing K, P

4. CONCLUSION

For CEC and KB parameters with high and very high criteria, while Phosphor (P 2O5)with very low to low criteria, for Potassium (K2O) values with very high, medium and low criteria. And C-organic criterion is very low to low.

The status of soil fertility in dry land of the study location at each SPL is medium with parameters that are limiting factors for soil fertility, namely available P and low organic C.

AUTHORS' CONTRIBUTIONS

In the collaborative pursuit of our research objectives, distinct roles have been assigned to key team members. Sri Handayani assumes the crucial responsibility of conducting field data collection, meticulously compiling research reports, and skilfully preparing article manuscripts. Budi Alhadi, on the other hand, focuses on field data collection, ensuring the efficient submission of samples to the laboratory, and providing valuable assistance in the comprehensive preparation of reports. Meanwhile, Cut Mulia Sari plays a pivotal role by actively participating in field data collection and providing valuable support in the thorough preparation of research reports. This strategic allocation of responsibilities ensures a synergistic effort among team members, enhancing the overall efficiency and efficacy of our research endeavours and adding organic matter so that soil fertility increases. For SPL 4, 5 and 6 with low C- organic and P content. Improvement efforts that can be done are by applying soil organic matter (manure, compost, green manure), applying organic mulch during soil management.

The relationship between soil testresults in the laboratory, relative results and fertilization recommendations for the CEC value category with high criteria is recommended to apply a little fertilizer to maintain fertility and very high KB values atthe study site are recommended not to be fertilized until the soil test goes down. While phosphorus values that have very low criteria are recommended, it needs to be given in normal fertilizer application for maximum yield. And for organic C values that have low criteria, it is recommended to apply fertilizer every year for maximum results and increase soil fertility.

ACKNOWLEDGMENTS

The author would like to thank the students who have helped carry out research in the field, laboratory officers and all parties involved in this research

REFERENCES

[1] F. Harahap, D. Harahap, and P. Harahap, "Soil Characteristics and Land Evaluation in Other Use Areas for the Development of Rice Crops in Salak District, Pakpak Bharat District,"*Ziraa'Ah Agricultural ScientificMagazine*, Vol. 45, No. 2, pp. 195–204, 2020.

[2] S. Z. and R. F. Ichriani, G.I., T.A. Atikah., *Compost Oil Palm EmptyBunches for Repair*. 2013.

[3] H. Damanik, M.M.B, B.E.H. Hasibuan, Fauzi Sarifuddin, and H, *Damanik, M.M.B, B.E.H. Hasibuan, Fauzi, Sarifuddin, and H, Hanum, 2010. Soil Fertility and Fertilization, USU-Press, Medan*. USU Press, 2010.

[4] S. L. Rajmi, Margarettha, and Refliaty, "Increased Availability of P Ultisol by Administration of Arbuscular Mycorrhizal Fungi," *Journal Agroecotania*, Vol. 1, No. 2, pp. 42–48, 2018.

[5] A. N. Susanto, "Mapping and Management of Soil Fertility Status," *Journal of Agricultural Technology Assessment and Development*, Vol. 8, No. 3, pp. 315–333, 2015.

[6] K. Tan *Fundamentals of Soil Chemistry*. Yogyakarta: Gajah Mada University Press, 1991.

[7] G. Gunawan, N. Wijayanto, and S. W. Budi, "Characteristics of Soil ChemicalProperties and Soil Fertility Status in Agroforestry of Eucalyptus Sp.-Based Vegetable Crops," *Journal of Tropical Silviculture*, Vol. 10, No. 2, pp. 63–69, 2019, DOI: 10.29244/J-Siltrop.10.2.63- 69.

[8] S. A. Barber, "Soil Chemistry and The Availability of Plant Nutriens.," in *Soil Chemistry and The Availability of Plant Nutriens.*, American Society of Agronomy, 1984, p. 22.

[9] P. M. K. S. K. K. T. P. D. L. U. T. B. K. D. K. K. K. B. M. I. P. Z. 39(1). 2014. pp. 30-36. D. https://ojs. UNISKA-BJM. air conditioning. id/index. php/ziraa. Rahmi, A. and Biantary, "Characteristics of Soil Chemical Properties and Soil Fertility Status of Yard and Farm Land of Several Villages in West Kutai Regency," *Ziraa'Ah Agricultural Scientific Magazine*Pp. 30–36, 2014. doi: DOI: https://ojs.uniska-bj.

[10] S. Suntoro, H. Widjianto, and T. Handayani, "Availability and Uptake of Mg Alfisol Peanuts with Kelud Volcanic Ash and Amendment Organic Fertilizer," *Agroscience: Journal of Agronomic Research*, Vol. 19, No. 1, p. 1, 2017, DOI: 10.20961/AGSJPA.V19I1.20920.

[11] P. F. N. Mulyawan I, Zamroni A, "Continuous Study of Milkfish Farming Management in Gresik," *Journal of Sosek KP Policy*, Vol. 1, pp. 25–35, 2016, doi: doi:10.15578/jksekp.v6i1.2607.

[12] Susila and Roedhy Poerwanto, "Irrigation and Fertigation," in *Irrigation and Fertigation*, 2013.

[13] D. I. Regency and K. West, "33-63-1-Sm," vol. 39, pp. 30–36, 2014.

[14] M. R. Alibasyah, "Changes in some physical and chemical properties of ultisol due to the application of compost and dolomite lime on terracedland," *J. Floratek*, Vol. 11, No. 1, pp. 75–87, 2016.

[15] PPT, "Technical Guidelines for Soil Fertility Evaluation," 1995.

[16] A. Munandar, "Munandar, A. Effect of Plant Media Composition and NPK Mutiara 16:16:16 fertilizer dose on the growth and yield of chili plants (Capsicum annum L.) Accompanied bythe Syiah Kuala University Postgraduate Program. Banda Aceh. 2013.," Syiah Kuala University, 2013