Comparison of Content and Status of the C-Organic, Nitrogen, C/N Ratio, Soil pH, and Organic Matter in Rainfed, Tidal and Swampy Rice Fields (Case Study in Three Villages, in East Kalimantan)

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Abstract. The purpose of the research is to identify the current condition of land fertility; for improvement and sustainability of land productivity, and for sustainable management actions. The research was carried out by taking 5 soil samples in 10 plots of rainfed rice fields, tidal rice fields and swamp rice field that had been determined, using a soil drill with a depth of ±30 cm; took 1 kg compositely from each of 5 samples and analyzed at the Laboratory of Soil Science, Faculty of Agriculture, Mulawarman University. The results of laboratory analysis provide information that: 1). Rainfed rice fields show, on average: C-organic content in moderate status (2.08%), Total N content in moderate status (0.34%), C/N ratio in low status (6.28), pH value in very acidic status (4.48), organic matter content, in moderate status (3.57%). 2). Tidal rice fields, showing the average: C-organic content in high status (3.27%), Total N content in moderate status (0.41%), C/N ratio in low status (7.89), pH value in very acidic status (4.28), organic matter content, in moderate status (3.58%); 3). Swamp Rice field, shows the average: C-organic content in high status (3.06%), Total N content in moderate status (0.46%), C/N ratio in low status (6.84), pH value in very acidic status (4.25), organic matter content, in high status (5.26%).

Keyword : comparison, C-Organic, Organic matter, rain-fed, tidal and swampy swamps

PRELIMINARY

Organic matter is important for the soil, most farmers use inorganic fertilizers more often to provide nutrients in the soil for plants, even though the use of inorganic fertilizers causes a decrease in soil quality, which will damage the soil and the production of plants planted will decrease in quantity and production quality, Soil organic matter is a collection of various complex organic compounds that are undergoing or have undergone a decomposition process, either in the form of humus or inorganic compounds resulting from mineralization, including heterotrophic and autotrophic microbes involved. In the management of soil organic matter the source can come from the application of organic fertilizers In the form of manure, green manure, compost, and biological fertilizers, organic matter has several important roles in the soil, namely as a provider of nutrients (especially nitrogen, phosphorus, and sulfur elements), increasing cation exchange capacity, as a food source for microorganisms, and functioning as a source of food for microorganisms. The main organic matter is as a soil enhancer, this makes organic matter important for the soil, organic material in the form of composted or fresh is useful for: 1) increasing soil organic matter levels, 2) improving physical, chemical, and biological fertility of the soil, 3) Increase diversity, population and activity microbes and facilitate the provision of nutrients in the soil, 4) Provide macro and micro nutrients

The harvested area of Indonesian rice crops in 2020 is 10 657 274.96 million ha with a production of 54 649 202.24 tons of dry milled rice (BPS, 2020), Currently, productive rice fields in Indonesia are experiencing challenges in terms of quantity and quality. The area of underproductive land is decreasing, due to land conversion. In terms of quality, productivity is decreasing due to the decline in land fertility. The decline in fertility of paddy fields is thought to be caused by mismanagement, which seeks to produce as much as possible, with an intensive farming system that focuses on one type of land. certain crops by utilizing technological innovations and the use of high “external inputs” (inorganic fertilizers, inorganic pesticides) to obtain higher outputs in a relatively short time, without the effort of applying organic fertilizers (compost, manure, green manure, organic matter) cause the land to be "tired".

Therefore, it is necessary to know the C-Organic status, C/N ratio, soil pH and organic matter content of paddy fields in East Kalimantan, which is a “driven” soil fertility, in order to identify the current fertility conditions for conservation of sustainable productivity; and for sustainable management actions, in anticipation of the plan to relocate the Capital of the Government of the Republic of Indonesia to the East Kalimantan region, which has implications for the 'exodus' of a number of human populations.

MATERIALS AND METHODS

Time and place

The time of the research, the research was carried out in February 2021, starting from preparation, sampling, sample preparation and chemical analysis at the Soil Science Laboratory, Agriculture Faculty, Mulawarman University.

Place of Research

Field research was carried out in Rainfed Paddy Fields in Sarinadi Village, Kota Bangun District, Kutai Kertanegara Regency; Tidal Paddy Fields in Sidomulyo Village, Anggana District, Kutai Kertanegara Regency and Rawa Lebak Rice Fields in Rawa Mulia Village, Babulu District, North Penajam Paser Regency, East Kalimantan

Materials and tools

Materials: 10 soil samples from each rainfed rice field in Sarinadi Village, Kota Bangun District, Kutai Kertanegara Regency; Tidal Rice Fields in Sidomulyo Village, Anggana District, Kutai Kertanegara Regency and Swampy Paddy Fields in Rawa Mulia Village, Babulu District, East Kalimantan PPU Regency, Total 30 samples

Tools: Soil drill, plastic clip, GPS, Camera, stationery, sample container

Procedure

The research implementation includes the following activities:

1. Taking each of 5 soil samples for each specified rainfed, tidal and swamp paddy field, using a soil drill with a depth of ±30 cm
2. Five (5) Soil samples from each rainfed, tidal and swampy paddy field were collected separately,
3. Each of the five soil samples was mixed and stirred evenly, 1 kg was taken compositely and put in a plastic clip,
4. The composites of each soil sample were brought to the Soil Science Laboratory, Faculty of Agriculture, Mulawarman University, to carry out soil chemical analysis procedures,
5. Limited soil chemical treatment and analysis – C-organic content, C/N ratio, soil pH and organic matter content - by the Laboratory of Soil Science, Faculty of Agriculture, Mulawarman University

Data analysis

The results of the chemical analysis are limited to the sample of rice fields that are the research site, in the three villages that have been determined, as follows:

Table 1. Results of Chemical Analysis of Limited Soil from Rainfed Rice Fields in Sarinadi Village, Kota Bangun District, Kutai Kertanegara Regency, East Kalimantan

No.	Code			organic C	Total N	C/N Ratio	pH	Organic matter (%)
	Sample	Lab	Coordinate	%				
1.	SP5 SD 1	6934	S 12994887,12 – E 44729,33	2,04 (M)	0,35 (M)	5,80 (L)	4,26 (VA)	3,51 (M)
2.	SP5 SD 2	6935	S 12994902,57 – E 44509,43	2,33 (M)	0,39 (M)	5,94 (L)	4,45 (VA)	4,01 (M)
3.	SP5 SD 3	6936	S 12994871,66 – E 45341,61	2,12 (M)	0,35 (M)	6,03 (L)	4,80 (A)	3,65 (M)
4.	SP5 SD 4	6937	S 12995128,06 – E 44789,13	1,82 (L)	0,27 (M)	6,78 (L)	4,29 (VA)	3,13 (L)
5.	SP5 SD 5	6938	S 12994522,05 – E 44679,55	2,55 (M)	0,39 (M)	6,61 (L)	4,54 (A)	4,39 (M)
6.	SP5 SD 6	6939	S 12995216,68 – E 44212,23	2,04 (M)	0,34 (M)	5,99 (L)	4,42 (VA)	3,51 (M)
7.	SP5 SD 7	6940	S 12994793,51- E 44287,14	2,48 (M)	0,31 (M)	8,05 (L)	4,27 (VA)	4,27 (M)
8.	SP5 SD 8	6941	S 12994277,13 – E 42224,27	1,62 (L)	0,29 (M)	6,50 (L)	4,67 (A)	2,79 (L)
9.	SP5 SD 9	6942	S 12994935,95 – E 42269,25	1,80 (L)	0,31 (M)	5,73 (L)	4,46 (VA)	3,10 (L)
10.	SP5 SD 10	6943	S 12994631,68 – E 42586,75	1,96 (L)	0,36 (M)	5,39 (L)	4,59 (A)	3,37 (L)
Average				2,08 (M)	0,34 (M)	6,28 (L)	4,48 (VA)	3,57 (M)

Description: Determination of status based on Table 4. M = Moderate, L=Low, VA=Very Acidic

Table 2. Results of Chemical Analysis of Limited Soil from Tidal Rice Fields in Sidomulyo Village, Anggana District, Kutai Kertanegara Regency, East Kalimantan

No.	Code			organic C	Total N	C/N Ratio	pH	Organic matter (%)
	Sample	Lab	Coordinate	%				
1.	ANG I SP 1	6945	S 00º 32’ 18,0” – E 117º 16’ 27,3”	3,45 (H)	0,38 (M)	9,19 (L)	4,10 (VA)	5,93 (H)
2.	ANG I SP 2	6946	S 00º 32’ 18,3” – E 117º 16’ 25,8”	2,93(M)	0,39 (M)	7,57 (L)	4,54 (A)	5,04 (M)
3.	ANG I SP 3	6947	S 00º 32’ 18,2” – E 117º 16’ 24,5”	2,71 (M)	0,27 (M)	9,89 (L)	4,35 (VA)	4,66 (M)
4.	ANG I SP 4	6948	S 00° 32' 7,06” – E 117° 16' 31, 6”	2.91 (M)	0,31 (M)	9,27 (L)	4,37 (VA)	5,01 (M)
5.	ANG I SP 5	6949	S 00° 32' 7,54" – E 117° 16' 40,52"	3,23 (H)	0,34 (M)	9,45 (L)	4,14 (VA)	5,56 (H)
6.	ANG II SP 1	6950	S 00° 32' 18,62" – E 117° 17' 2,8"	3,88 (H)	0,58 (M)	6,69 (L)	3,86 (VA)	6,67 (H)
7.	ANG II SP 2	6951	S 00º 32’ 9,8” – E 117º 16’ 54,6”	3,30 (H)	0,48 (M)	6,82 (L)	4,17 (VA)	5,68 (H)
8.	ANG II SP 3	6952	S 00º 32’ 17,9” – E 117º 16’ 54,9”	2.13 (M)	0,35 (M)	6,06 (L)	4,25 (VA)	3,66 (M)
9.	ANG II SP 4	6953	S 00º 32’ 23,0” – E 117º 16’ 58,0”	3,36 (H)	0,48 (M)	7,06 (L)	4,28 (VA)	5,78 (H)
10.	ANG II SP 5	6954	S 00º 32’ 23,0” – E 117º 17’ 02,7”	3,27 (H)	0,48 (M)	6,86 (L)	4,80 (A)	5,62 (H)
Average				3,27 (H)	0,41 (M)	7,89 (L)	4,28 (VA)	3,58 (M)

Description: Determination of status based on Table 4. M = Moderate, L=Low, VA=Very Acidic

Table 3. Results of Chemical Analysis of Limited Soil from Swampy Rice Fields in Rawa Mulia Village, Long Kali District, North Penajam Paser Regency, East Kalimantan

No.	Code				organic C	Total N	C/N Ratio	pH	Organic Matter (%)
	Sample	Lab	Coordinate		%				
			X	Y					
1.	RM Sdr 5	6934	12965680.89	-173954.3713	2,57 (M)	0,40 (M)	6,38 (L)	4,23 (VA)	4,42 (M)
2.	RM Sdr 11	6935	12965468.68	-173635.7675	3,73 (H)	0,51 (H)	7,32 (L)	4,40 (VA)	6,42 (H)
3.	RM Sdr 15	6936	12965627.48	-173643.5137	2,07 (M)	0,31 (M)	6,73 (L)	4,10 (VA)	3,56 (M)
4.	SMD 3	6937	12965806.61	-173669.657	3,16 (H)	0,45 (M)	7,05 (L)	4,16 (VA)	5,44 (H)
5.	SMD 4	6938	12965696.22	-173726.785	2,18 (M)	0,36 (M)	6,08 (L)	4,34 (VA)	3,75 (M)
6.	BAM 6	6939	12965392.63	-173497.607	3,53 (H)	0,60 (H)	7,08 (L)	4,11 (VA)	6,07 (H)
7.	BAM 11	6940	12965389.28	-173432.4259	3,00 (M)	0,43 (M)	6,96 (L)	4,20 (VA)	5,16 (M)
8.	BAM 13	6941	12965542.27	-173767.4524	2,98 (M)	0,49 (M)	6,05 (L)	4,37 (VA)	5,13 (M)
9.	DA 2 S 01	6942	12965733.99	-173851.692	3,86 (H)	0,57 (H)	6,77 (L)	4,40 (VA)	6,64 (H)
10.	DA 2 S 02	6943	12965529.68	-173924.3124	3,50 (H)	0,44 (M)	7,95 (L)	4,19 (VA)	6,02 (H)
Average					3,06 (H)	0,46 (M)	6,84 (L)	4,25 (VA)	5,26 (H)

Description: Determination of status based on Table 4. M = Moderate, L=Low, VA=Very Acidic

Determination of the status of the results of chemical analysis on 10 samples of Tidal Rice Fields in Sidomulyo Village, Tadah Rice Fields in Sari Nadi Village and Swampy Rice Fields in Rawa Mulia Village, using the table below:

Table 4. Criteria for Assessment of Soil Chemical Properties for Agriculture – Best Conditions for Soil Fertility – Bogor Agricultural Research Institute

No.	Chemical Soil Properties	Method of Analysis	Very Low	Low	Moderate	High	Very High
1.	C (%)	Walkley and Black dichromate method	< 1,0	1,0 – 1,9	2,0 – 2,9	3,0 – 5,0	> 5,0
2.	Organic Matter	Multiply C content by 1.72	< 1,72	1,71 – 3,27	3,28 – 4,99	5,0 – 8,6	> 8,6
3.	N (%)	Kjehldahl method	< 0,10	0,10 – 0,20	0,21 - 0,50	0,51 – 0,75	> 7,5
4.	C/N ratio	Dividing C content by N content	< 5	5 - 10	11 - 15	16 – 25	> 25
5.	pH H_2O	Very Acidic < 4,5	Acid 4,5 – 5,5	Slightly Acid 5,6 -6,5	Neutral 6,6 – 7,5	Slightly Alcaline 7,6 – 8,5	Alcaline > 8,5

Sumber : Balittanah, Bogor

RESULT AND DISCUSSION

Results

C-organic

Results Based on laboratory analysis, it is known that the average C-organic content in rainfed rice fields in Sari Nadi Village is moderate status (2.08%); tidal rice fields in the village of Sidomulyo and swampy rice fields in the village of Rawa Mulia, in high status; namely 3.27% and 3.06%, respectively.

Total N

The results of the analysis of samples of paddy fields studied in the soil science laboratory, it was found that the average total N content in all samples of paddy fields; rainfed, tidal and lowland swamps, showing moderate status, namely respectively: 0.34%, 0.41% and 0.46%

C/N ratio

In the parameter C/N ratio studied on all samples of paddy fields; rainfed, tidal and lowland swamps, by the soil science laboratory, information was obtained that the average C/N ratio showed a low status, respectively: 6.28; 7.89; and 6.84.

pH

Results of laboratory analysis of soil samples taken from the field; rainfed, tidal and lowland swamps, showing very acidic status, namely: 4.48; 4.28 and 4.25.

Organic matter content

Observation of parameters of organic matter content in all soil samples, provides information that the average number of soil organic matter content; rainfed, tidal and swampy rice field, indicating medium and high status; respectively : 3.57%; 3.58%, and in high status, namely: 5.26%

Table 5. Comparative summary of soil chemical properties of each paddy field

No.	Chemical Soil Properties	Paddy Field		
		Rainfed	Tidal	Swampy
1.	C (%)	2,08 (M)	3,27 (H)	3,06 (H)
2.	N (%)	0,34 (M)	0,41 (M)	0,46 (M)
3.	C/N ratio	6,28 (L)	7,89 (L)	6,84 (L)
4.	pH	4,48 (VA)	4,28 (VA)	4,25 (VA)
5.	Organic Matter (%)	3,57 (M)	3,58 (M)	5,26 (H)

Discussion

C-organic

Following the criteria for assessing soil properties for agriculture, in the best soil fertility conditions by Balittanah Bogor (2009), the organic C content in high status is in the range, 3.0% - 5.0%. According to Friyanto (2020), at a C-organic content of 3-5%, the balance of the soil ecosystem is still maintained. Soil microbes still get adequate food intake from soil organic C, both beneficial and unbeneficial microbes.

The factors that affect the organic matter content in the soil include: climate, vegetation/soil organisms, topography, parent material and cropping management. Human activities are part of agricultural management, through the provision of organic fertilizers will determine the organic content of the soil will affect the organic matter content of the soil.

Based on the results of the analysis, it was found that the rainfed rice fields in the village of Sari Nadi were in the medium category; tidal rice fields and swampy swamp rice fields, in Sidomulyo village and Rawa Mulia village, respectively, were in the high category (close to the medium category). For the conservation of sustainable land productivity; and for management actions, it is necessary to improve the cultivation system, through the provision of organic fertilizers to complement inorganic fertilizers, as well as efforts to manage organic matter left over from harvests on the land. This is in line with the results of research by Yuniarti, et al (2019), which showed that the application of various organic fertilizers and fertilizers N, P and K had an effect on the content of organic C, C/N, and N uptake in the soil inceptisols.

N Total

Nitrogen element, plays a very important role in the formation of plant cells, tissues, and plant organs. Nitrogen has the main function as a synthetic material for chlorophyll, protein, and amino acids. The characteristics of nitrogen-deficient plants can be recognized from the lower leaves. The leaves in this section turn yellow due to lack of chlorophyll. In further processing, the leaves will dry up and fall off. The bones under the surface of the young leaves will appear pale. Plant growth is slow, stunted and weak. As a result, flower and seed production will be low (Mukhlis, 2017). Nitrogen elements, in plant or plant biomass, were found in Turi mini (*Sesbania rostrata*) aged 45 days producing the highest average nitrogen content (5.1%) (Baba, et al. 2020); Kirinyu 2.48%; Gamal 3.09% and Lamtoro 3.01% (Pu'u, YMSW and C. Mutiara. 2018), papaya, Gliricidia, cassava, binahong, moringa, sweet potato, *cromolaena*, peanut, and African plants, the leaves contain nitrogen which is quite dominant (Pradana, WE 2020)

Based on the results of laboratory analysis, it was found that the total N content in all samples of paddy fields; rainfed, tidal and lowland swamps, indicating moderate status. For sustainable conservation of land productivity, it is necessary to improve cultivation, especially in nitrogen fertilization, it must be combined with green manure, foliar compost, and manure. The above is in line with Hutomo et al (2015) that the application of green manure *Tithonia diversifolia* at a dose of 10 $Mg.ha^{-1}$ can increase maize yields by 9.2 $Mg.ha^{-1}$. Nisaa', et al (2016), the addition of green manure *Clotalaria juncea* 25 $Mg.ha^{-1}$ can reduce the use of inorganic fertilizers by 50% and the addition of green manure *Clotalaria mucronata* 25 $Mg.ha^{-1}$ can reduce the use of inorganic fertilizers by 25%.

C/N ratio

A high C/N ratio indicates the presence of a relatively large amount of weathered soil material (eg cellulose, fat and wax), on the other hand, a smaller C/N ratio indicates that organic matter is more easily decomposed. The C/N ratio will affect the availability of nutrients, the C/N ratio is inversely proportional to the availability of nutrients, if the C/N ratio is high then the nutrient content is slightly available to plants, whereas if the C/N ratio is low then the availability of nutrients is high and plants can meet their needs. Soil C/N ratio ranges from 10-12. If the organic matter has a C/N ratio close to or equal to the soil C/N ratio, then the material can be used by plants. Organic matter that can be absorbed by plants is organic material with a C/N ratio close to the soil C/N ratio, which is about 12-15 and a temperature almost the same as the ambient temperature.

Based on the results of the analysis, it is known that all observed samples show the C/N ratio parameter is in a low status, it is necessary to increase this number by applying organic fertilizer or organic matter, which in practice can be done by increasing weed biomass after harvesting and returning crop residues to paddy fields.

pH

The ideal soil acidity (pH) for plants is between pH 5.5 – 7.5. If the soil or planting medium has a high acidity level, then the elements of magnesium, calcium and phosphorus will be chemically bound so that they cannot be absorbed by plants. In such conditions, the elements of aluminum and manganese will be toxic and detrimental to plants. The availability of nutrients for plants decreases and there is a decrease in crop production. If the soil or growing media has a high alkaline level (alkaline), micro nutrients such as copper, manganese, zinc and iron will be chemically bound and cannot be absorbed by plants. Soil acidity is caused by utilization without a break, and the excessive use of chemical fertilizers, the Neurafarm Team (2021), conveyed how to deal with acid soil by (1) liming, (2) intensive application of organic matter, (3) intensive phosphate fertilizer application, (4) conducting regulation of cropping systems and, (5) Provision of decomposing microorganisms.

Based on the results of the analysis on the pH parameters, all samples showed a very acidic status. This is very critical to the sustainability of the productivity of the paddy fields. So it is necessary to immediately handle the above through liming with Dolomite $CaMg(CO_3)_2$ gradually, as well as the provision of organic fertilizer. Provision of animal manure can increase soil chemical properties such as pH, C-organic and N-total (Palupi, 2015)

Organic matter content

Organic matter in the soil has 2 roles: as a storage (has a high cation exchange capacity) and a supplier of essential nutrients for plants (through weathering of biomass). Able to improve physical properties (forming soil structure) and soil chemistry (eg pH buffer) and soil biology. According to Friyandito (2020) Some sources of soil organic matter addition are: plant residues, green manure, manure, industrial waste, household waste.

Based on the results of the analysis on the parameters of the organic matter content, the rainfed rice fields in Sari Nadi Village showed the medium category, the others were high. Immediate treatment is needed to increase the number of organic matter content in medium status paddy fields, and maintenance at high status through the provision of soil organic matter additives.

CONCLUSIONS AND SUGGESTIONS

Conclusion

Based on the results of laboratory analysis on 30 samples taken from rainfed rice fields in Sari Nadi Village, Tidal Rice Fields in Sidomulyo Village and Swampy Rice Fields in Rawa Mulia Village, with the aim of identifying current fertility conditions, for conservation of productivity sustainability; and for sustainable management actions, it can be concluded as follows:

1. Samples of rainfed rice fields in Sari Nadi Village showed that Organic C content, moderate (2.08%); total N content, moderate (0.34%), low in C/N ratio (6.28), pH soil was very acidic (4.48) and organic matter content, moderate (3.57%); in samples of tidal rice fields in Sidomulyo Village, showed that the organic C content was high (3.27%), total N content was moderate (0.41%), C/N ratio was low (7.89), soil pH was very acidic (4.28) and organic matter content was moderate (3.58%); in the swampy rice fields in Rawa Mulia Village, showed high Organic C content (3.06%), total N content was moderate (0.46%), low in C/N ratio (6.84), soil pH very acidic (4.25) and organic matter content was high (5.26%),
2. The sustainability of the land productivity of all the rice fields studied will decline in the future if soil acidity is not immediately corrected,
3. It is necessary to take action to conserve the sustainability of productivity, immediately, on the parameters of pH, C/N ratio, and organic C, while on other parameters, maintenance actions need to be taken.

Suggestion

Based on the latest fertility conditions from the results of laboratory analysis on sample samples from rainfed rice fields, tidal rice fields and lebak swamp rice fields, it is recommended:

1. It is necessary to handle the acidity of the rice fields above through liming with Dolomite $CaMg(CO_3)_2$ gradually,
2. It is necessary to handle the parameters of organic C, C/N ratio, N content and organic matter content through intensive application of organic matter/organic fertilizer.

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