Pembandingan Penilaian Kesehatan Tanah antara Indikator Kinerja Tanah dengan Indikator Pertumbuhan Tanaman Selada

Soil Performance Indicator as A Soil Health Assessment in Correspond to Lettuce Growth Indicator

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ABSTRACT

The purposes of the research were to assess and classify soil health from Padang Betuah area of Bengkulu, and to compare between soil health indicators and lettuce plant performance indicators. Soils, consisted of mineral and peat soils, were sampled using soil random sampling technique. Lettuce plants were grown in poly bags of sample soils. Both lettuce performance and soil health were assessed by summed up the percentage of total scores of lettuce plant or soil performance indicators derived from variables observed. The soil variables for field evaluation included soil color, moisture, texture, structure, compaction, land's slope, organic matter, pH, amount of earthworm, erosion level, LCC (Legume Cover Crop), and vegetation performance. Variables for soil laboratory evaluation were pH, electrical conductivity capacity, total Carbon and Nitrogen, available-P, cation exchangeable capacity, base saturation, and aluminum saturation. While the variables for lettuce growth performance included plant height, numbers of leaf, degree of leaf greenness, plant fresh weight, and relative percentage of shoot : root ratio. The result of field and laboratory evaluation showed that soil health categories were indicated as healthy soil and medium healthy soil both for mineral and peat soils. Furthermore, the same categories were also obtained for evaluation of plant performance categories.

Key words: soil health, field indicator, laboratory indicator, lettuce growth indicator

INTRODUCTION

Soil is an important factor to increase agricultural production, to keep and attain water health and quality, as a home of various organisms, as a filter and neutralizer of poisoning substances (NRCS, 1996, Riwandi, 2007). Maintaning soil health then would be very important in order to sustain the soil function.

Soil health in an integration and optimalization among various soil properties (physical, chemistry, and biological), the condition of which would increase productivity and quality of plant, soil and environment (Idowu, *et al.* 2008a,b, Gugino *et al.*, 2007). Soil health is a combination and an optimum of soil properties (physical, chemical, and biology) to increase quality and productivity of soil, plant, and environment. Soil health is the capability of soil to perform the productivity without depleting environment quality in the future (Johnson, 2009. from Soil Health Group, Cornell University).

Soil health assessment was obtained based on soil performance indicators, that is a measureable soil properties and they give signs that soil does its function naturally. These are possible if only the soil has good properties, but it is not always function properly. Soil will function as it is whenever the interaction between one property and the others give a mutualistic synergy both to the soil health and quality. For example, soil with an ample amount of organic matter will be able to ameliorate Al effect by chelating Al to the organic matter.

This soil will also serves the essensial elements for plant growth and development, soil water content, and creates a healthy environment for plant growth and soil microorganisms. The proper interactions among physical, chemistry, and biology properties will perform healthy soil and finally healthy plants.

Healthy soil needs a system that capable to regulate the system itself under the exsistance of physical, chemical, and biological properties to perform the soil functions. The continuous application of sinthetic fertilizers and pesticides can destroy the soil functions.

Soil health category was designed basely on the soil performance indicator scores, i.e. Very Healthy (VH) score range 81% - 100%, Healthy (H) 61% - 80%, Moderate (M) 41%-60%, Less Healthy (LH) 20%-40%, and Unhealthy (UH) <20%. Soil properties measured on field include soil color, soil water content, slope, texture, structure, soil organic matter, pH, earthworm population, erotion, soil compaction, and vegetation performance. Soil properties analyzed in laboratory include pH – H_2O, pH – KCl, C-total, N-total, P-available, CEC, bases and Aluminium saturation.

All those soil properties are scored from 1 to represent <20% to 5 to represent 100% (OSU Center, 2009). In case of any soil property(ies) not included in that scoring criteria, the score was made and modified according to our reasonable purpose.

The assessment criteria for soil performance indicators on field is presented in Table 1.

Table 1. Assessment criteria and the score for soil performance indicator on field

Soil Performance Indicator	UH (score 1)	LH (score 2)	M (score 3)	H (score 4)	VH (score 5)
Soil Color	Red	Yellow	Green	Brown	Black
Soil Moisture Content	>75%	<25%	75%	50%	25-50%
Slope	>30%	15-30%	8-15%	3-8%	0-3%
Texture	Sand/clay	Silty sand	Sandy clay	Silty clay	Clay
Peat Maturity	Fibris	-	Hemis	-	Sapris
Soil structure	Very hard	Hard	Less loose	Loose	Very loose
Organic Matter	None	Small amount	Moderate	Large amount	Abundant
pH (H_20)	<4,5	4,5-5,5	7,6-8,5	5,5-6	6-7,5
Earthworm Population	none	Small amount, faeces, & earthworm holes	moderate, faeces, & earthworm holes	Large amount, faeces, & earthworm holes	Abundant, Faeces, & earthworm holes
LCC	<45%	45-64%	65-74%	75-99%	100%
Soil Erosion	Big Gully	Small Gully	Gully	Lembar	None
Soil Compaction	Hard, compact, bad root penetration	Hard, compact	Firm, Restricted Root Penetration	Loosely soil	Freely Root penetration
Vegetation Performance	White leaves, stunted, element stress	Stunted, element stress	Plants grow moderately, less element stress	Leaves green, no element stress	Leaves green, normal growth, no element stress

Source: Bierman (2007) modified to fit to local area and condition

Assessment criteria for soil analyses in the laboratory is presented in Table 2.

Table 2. Assessment criteria and scoring for soil analyses in the laboratory

Soil Properties	Very Low (score 1)	Low (score 2)	Moderate (score 3)	High (score 4)	Very High (score 5)
C (%)	<1	1-2	2-3	3-5	>5
N (%)	<0,1	0,1-0,2	0,21-0,50	0,51-0,75	>0,75
P2O5 Bray (ppm P)	<4	5-7	8-10	11-15	>15
KTK (cmol(+)/kg)	<5	5-16	17-24	25-40	>40
Ca (cmol(+)/kg)	<2	2-5	6-10	11-20	>20
Mg(cmol(+)/kg)	<0,3	0,4-1	1,1-2,0	2,1-8,0	>8,0
K(cmol(+)/kg)	<0,1	0,1-0,3	0,4-0,5	0,6-1,0	>1,0
Bases saturation (%)	<20	20-40	41-60	61-80	>80
Al saturation (%)	<5	5-10	11-20	20-40	>40
DHL(dS/m)	<1	1-2	2-3	3-4	>4

Source: Balittanah (Bureau of Soil Research), Bogor (2005)

Table 3. shows the assessment criteria indicators for lettuce plant.

Tabel 3. Assessment criteria indicators for lettuce plant.

Growth Indicators	Score
Plant height	0-6 cm = 1; 7-12 cm = 2; 13-18 cm = 3;19-24 cm = 4; 25-30 cm = 5
Degree of leaf greenness	0-8 = 1; 9-16 = 2; 17-24 = 3; 25-32 = 4; 33-40 = 5
Shoot/root ratio (% relative)	0-20% = 1; 21-40% = 2; 41-60% = 3; 61-80% =4; 81-100% =5
Number of leaves	0-2 = 1; 3-4 = 2; 5-6 = 3; 7-8 = 4; >8 = 5
Plant fresh weight	0-20 g = 1; 21-40 g =2; 41-60 g = 3; 61-80 g = 4; >80 g = 5

The urgency of this research is that soil as natural source has been contaminated with many pollutants because of human activities in agriculture (the usage of syntetic fertilizers and pesticides, and mismanagement on soil). This assumption should be proven. To the farmers this research was expected to help them to choose the healthy soil of the agricultural land sites and dicide which piece of land the most fit to grow their plants. Growing plants on healthy soil can cut production costs with better harvesting products. The objectives of this research were: 1) to assess soil health using soil performance indicators, 2) to classify soil health, and 3) to correspond the lettuce plant growth to the soil health.

MATERIALS AND METHODS

Research was conducted on April until July 2009 in Padang Betuah, Pondk Kelapa District, Central Bengkulu. To the west of the area is the Ocean of Indonesia, to the east is Pondok Kelapa Village, to the north is Lais District, and to the south is Bengkulu City. The geographical points of the area in this research are coordinates of X = 57605 to 59072 and Y = 1096505 to 1095089. It comprised the area of 250 hectares consisted of 30% mineral and 70% peat soils.

Soil random sampling was used as research design. The lowland area of 210 ha and upland area of 40 ha were sampled in random. The slope area was determined according to slope direction (upper, middle, and lower slopes according to Bureau of Soil Research, Bogor . Balittanah, 2004a,b,c; 2005). The number of soil samples to represent the mineral and peat soil were 18 samples. The coordinate points of the soil samples are presented on Table 4.

Table 4. Coordinate points of sample soils.

No	Point Number	Coordinate		
		UTM	X	Y
1	3	48M 191182 9595909	57824	1096164
2	4	48M 190962 9596250	57605	1096505
3	5	48M 191096 9596622	57740	1095609
4	13	48M 191718 9595354	58359	1095609
5	14	48M 191462 9595098	58103	1095353
6	16	48M 191242 9595281	57883	1095536
7	9	48M 192019 9594148	58658	1094439
8	1	48M 190808 9595228	57449	1095484
9	10	48M 192432 9594835	59072	1095089
10	11	48M 191926 9595872	58568	1096126
11	12	48M 191423 9595757	58065	1096012
12	15	48M 191293 9594720	57843	1094976
13	17	48M 191352	57995	1096479
14	18	48M 191841 9596399	58484	1096653
15	2	48M 190936 9595562	57578	1095817
16	6	48M 191955 9594942	58595	1095196
17	7	48M 191768 9594758	58408	1095013
18	8	48M 191687 9594243	58326	1094498

There were four steps in the soil health assessment, they were soil obervation, scoring for soil performance indicators, laboratory analyses, soil health classification, and bioassay research for lettuce plant.

Step 1. Points for soil sampling on the field were determined. Soil performance indicators were observed and recorded on the Soil Health Assessment Forms. Soils were sampled in the depth 0 cm to 20 cm using soil borer and were repeated 9 time with interdistance 50 cm. All nine samples were mix thoroughly in a big bucket, soil was separated from plant fragmentations, stones and gravels to get a 2 kg soil composite.

Step 2. Scoring to each soil performance indicator on the field was done by scoring 1 to the lowest soil performance indicator, and scoring 5 to the highest one. Every indicator than was summed up to get total scores. Classing of soil health was determined according to the total score of the observed point of soil.

Step 3. Analyses of sampled soil in the laboratory. The sample was air dried, shaked on the filter shaker with diameter 0.5 mm. Sampled soil was than ready for analyses. Soil chemistry properties consisted of pH (H_2O), DHL, C- and N-total, available-P, base saturation (sum of kations of K, Ca, Mg devided by CEC x 100%, and Aluminium saturation (Al devided by CEC x 100%). Every soil chemistry property was scored according to criteria from Bureau of Soil Research (Balittanah, 2005). Step 4. Determining soil health class based on the percentage of total scores of observed point of soil. The soil health classes were Very Healthy, Healthy, Moderately Healthy, Less Healthy, and UnHealthy..

The pH (H_2O) was measured with proportionn soil : distilled water 1 : 2.5 w/v, measured using pH meter (Conway). DHL- measured using proportion soil : distilled water = 1 : 1, measured with EC meter (Jenway). Total Carbon was measured using

Walkley and Black Method. Nitrogen was measured using Kjeldhal method. P2O5-Phosphor was extracted using Bray 1 method and analysed using UV-Vis Spectrofotometer (PG Instrument Ltd.). Exchanged-base (K-, Ca-, and Mg – echangeable) was extracted using Acetic Ammonium 1 N, pH 7, and exchangeable K (K-exc) was measured using Flamefotometer, Calsium (Ca-exc) and Magnesium (Mg-exc) measured using titrated method with EDTA 0.005M. Aluminium and Hidrogen were extracted with KCl 1 N and measured using titrated method with H2SO4 0.1 N.

Data of soils assessment were plotted and the total scores were used to categorized the soil health into one of the five categories as stated above. To compare the soil performance indicators and lettuce plant iindicators, data of the two observations were analyzed using t-test 0.05. If the result was significant, it means the assessment method can not be applied so another method should be introduced.

RESULT AND DISCUSSION

The topography of research area is level land with total area of 210 ha and light slope with total area 40 ha. The area with peat type covers 70%, whereas mineral type covers 30%. The landuse of level peat soil area was dominated by paddy. Palm oil plantation was commonly found on slopy mineral soil. The peat soil in this area is unique because it is not influenced by tidewater, mainly consisted of woody remains especially from angiosperm, and originated from the *in situ* formation with topogenic peat as the result of slope effect that supplied mineral soil materials to the peat area.. The spread of peat downstream usually reached 10 – 50 km from the sea line (Ritung & Wahyunto, 2002).

Table 4 showed that the area fall to class Moderate Healthy and Healthy based on the 12 indicators observed on field. Three soil samples of mineral soils and the same replication of peat soil, each of those represented moderate healthy and healthy soil, were analyzed in laboratory for soil chemistry properties. This resulted more accurate than field observation but laboratory prosedure takes longer time. Field analyses could be reliable method and more practical especially for farmers. But the farmers should be trained so they get used to assess soil indicator performances.

Soils with category Moderate Healthy were obtained from PB5 and PB12 (mineral soils) and PB6 (peat soil). Healthy soils were PB77 (mineral) and PB13 as well as PB14 (peat soils). Following field observations and categorization, soil measurement was continued to laboratory analyses. It is an important step since field categorization is greatly depend on the accuracy of person (s) during the observations. Inspite of this fact, both field and laboratory works are interdependent to get the whole picture of soil status.

Table 4. Soil health categories from Padang Betuah, Pondok Kelapa, Central Bengkulu

Code No.	Soil Type	Landuse	Color	Wtr contnt	Slope	Textu re	Struc ture	OM	pH	Earthw popl	Cover crop	Erosi	Soil cmpct	Vegeta tion	Tot Score	%	Cate gory
PB1	Mineral	Bush	4	4	3	1	3	5	1	1	1	5	3	5	36	60%	M
PB2	Mineral	Palm oil	4	4	3	1	3	3	1	3	1	5	1	3	32	53%	M
PB3	Mineral	Palm oil	4	5	5	3	3	3	2	1	1	5	3	3	38	63%	H
PB5	Mineral	Palm oil	4	2	5	2	2	3	1	5	1	4	2	1	32	53%	M
PB7	Mineral	Paddy	4	5	4	1	5	2	2	3	1	5	5	3	40	67%	H
PB8	Mineral	Grass	2	2	5	2	2	2	5	1	2	5	2	2	32	53%	M
PB12	Mineral	Bush	4	4	4	2	1	3	2	2	2	4	2	2	32	53%	M
PB17	Mineral	Palm oil	5	3	3	2	5	5	1	1	1	5	5	2	38	63%	H
PB18	Mineral	Palm oil	3	5	5	2	2	2	1	1	2	5	2	2	32	53%	M
PB4	Peat	Palm oil	5	5	5	5	5	5	1	1	2	5	2	5	46	77%	H
PB6	Peat	Palm oil	5	5	5	5	1	5	2	1	1	4	1	1	36	60%	M
PB9	Peat	Bush	4	4	5	5	2	5	2	1	2	5	2	2	39	65%	H
PB10	Peat	Grass	5	5	5	5	1	5	2	1	1	4	2	1	37	62%	H
PB11	Peat	Corn	5	2	5	5	1	5	2	1	1	5	2	1	35	58%	M
PB13	Peat	Bush	5	5	5	2	5	5	1	5	2	5	5	1	46	77%	H
PB14	Peat	Paddy	5	5	5	5	2	5	2	1	1	5	5	5	46	77%	H
PB15	Peat	Paddy	5	5	5	5	1	5	2	1	1	5	4	5	44	73%	H
PB16	Peat	Paddy	5	5	5	5	3	5	2	1	5	5	3	5	49	82%	H

Table 5. showed that soil chemistry properties of the soil samples were categorized as healthy except on bases saturation which showed very low level. It means the availability of the nutrition elements to plants is low. The unavailability of the elements is due to the low capacity of soil to hold and to exchange the elements. This is indicated from the data observed that the CEC of mineral and peat soils were low. The soil had low pH indicated that it was acid soil, and it was also another factor that impose the low availability of nutrient elements. Eventhough the C-organic of the peat soil is very high (score 5), it is not strong enough to support the CEC, bases saturation, and to ameliorate high Al saturation.

Table 6. indicated that 3 variables of growth of lettuce plants (plant height, leaf greenness, and number of leaves) were in category healthy, while shoot/root ratio was very low. Plants fresh weight were vary. Total categories, lettuce plants were in moderate and healthy categories and this corresponded to the results from soil performance indicators. It was supported from the t-test showing that it fitted the significancy of 95%.

Table 5. Laboratory analyses and scoring of properties of soils from Padang Betuah, Pondok Kelapa, Central Bengkulu

Code no.	pH		DHL		C	Score C	N	Score N	P_2O_5	Score P	CEC	Score CEC	Base-satrn	Score Base	Al satrn	Score - Al	Score total	%	Category
	H_2O	Score	dS/m	Score	%		%		ppm		me/100g		%		%				
PB5 –M	4.3	1	0.079	5	7.40	5	0.64	4	22.85	5	30.35	4	5.67	1	27.48	2	27	68%	H
PB7 –M	5.5	3	0.053	5	5.35	5	0.55	4	7.37	3	17.14	3	8.40	1	22.40	2	26	65%	H
PB12 –M	4.2	1	0.058	5	21.8	5	1.35	5	20.05	5	16.01	3	7.43	1	21.49	2	27	68%	H
PB6 –P	4.2	1	0.056	5	36.3	5	0.37	3	38.28	5	8.54	2	33.14	2	49.77	1	24	60%	M
PB13 –P	4.8	2	0.515	5	20.9	5	0.37	3	1.67	1	39.71	4	7.08	1	9.14	4	25	63%	H
PB14 g	4.6	2	0.046	5	34.9	5	1.97	5	83.47	5	18.71	3	31.11	2	18.76	3	30	75%	H

M=mineral; P =Peat

Table 6. Lettuce growth measurement and health scoring from plant bioassay test.

Code No.	Soil Type	Land use	Plant height	Score	Leaf greenness	Score	Shoot/ Root ratio	Score	Σ leaves	Score	Fresh wght	Score	Total Scores	%	Category
PB5	M	Palm oil	16	3	24	3	5	1	12	5	51	3	15	60	M
PB7	M	Paddy	15	3	17	3	5	1	9	5	20	1	13	52	M
PB12	M	Bush	15	3	45	5	6	1	10	5	21	2	16	64	H
PB6	P	Palm oil	21	4	22	3	9	1	12	5	42	3	16	64	H
PB13	P	Bush	14	3	23	3	4	1	9	5	17	1	13	52	M
PB14	P	Paddy	18	3	27	4	8	1	13	5	63	4	17	68	H

CONCLUSION

It can be concluded that the assessment of soil health using soil performance indicator approach, both on field (qualitative, quick, less accurate) and laboratory approach (quantitative, time consuming, accurate) was reliable. The categories of Padang Betuah soils were moderately healthy and healthy. The response of lettuce plant upon the types of soils was 95% significant. It showed that soil health categories based on lettuce growth variables corresponded to soil health categories based on soil performance indicators.
Further research is needed for other different types of soils so that soil health assessment method could be applied on sol types in this area.

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