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CHANGES IN SOIL AGGREGATE, BULK DENSITY AND SOIL PERMEABILITY RATE AS THE INDICATORS OF SOIL CRUST PROCESS THROUGH THE USE OF CHICKEN MANURE AND PAM UNDER INTENSE RAINFALL WITH ONE DAY DRAINAGE PROCESS

PERUBAHAN AGREGASI TANAH, BERAT VOLUME DAN LAJU PERMEABILITAS TANAH SEBAGAI INDIKATOR PROSES PENGERAKAN TANAH MENGGUNAKAN PUPUK KANDANG AYAM DAN PAM PADA CURAH HUJAN INTENSIF DENGAN PROSES DRAINASE SEHARI

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ABSTRACT

Soil crust is a soil surface layer which is more compact, hard, and brittle when dry than underlaying material. Soil aggregate stability, bulk density and soil permeability rate are closely related to this process.

This experiment was conducted to evaluate the effects of chicken manure doses and certain chicken manure with PAM (Polyacrile Amide) on soil aggregate, bulk density and soil permeability rate. The result of this research, are : (1) an incremental addition of chicken manure into soil will increase soil aggregation percentage, soil stability and soil permeability rate, (2) the combined incremental additions of chicken manure with PAM were found to be more effective than only an incremental additions of chicken manure, increasing the aggregation percentage, soil aggregate stability, from the soil one day drainage process, but another case in decreasing the bulk density permeability rate from the soil with the same process.

Key words : bulk density, chicken manure, crust, PAM, aggregate, permeability

INTISARI

Kerak tanah adalah lapisan permukaan tanah yang lebih padat, keras, dan kasar saat kering bila dibandingkan dengan lapisan dibawahnya Stabilitas agregat tanah, berat volume dan laju permeabilitas tanah berkaitan erat dengan proses ini.

Percobaan ini dilaksanakan untuk mengevaluasi pengaruh dosis pupuk kandang ayam dan campuran pupuk kandang ayam dengan PAM (Polyacrile Amide) terhadap agregat tanah, berat volume dan laju permeabilitas tanah. Hasil percobaan ini adalah: (1) penambahan pupuk kandang ayam ke dalam tanah akan meningkatkan persentase agregasi tanah, stabilitas tanah dan

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laju permeabilitas tanah, (2) kombinasi penambahan pupuk kandang ayam dengan PAM ternyata lebih efektif bila dibandingkan dengan pupuk kandang ayam saja dalam meningkatkan persentase agregasi, stabilitas agregat tanah, dari proses drainase dalam sehari, tetapi berlainan hal dalam penurunan berat volume laju permeabilitas dari tanah dengan proses yang sama.

***Kata kunci** : berat volume, pupuk kandang ayam, kerak, PAM, agregasi, permeabilitas.*

INTRODUCTION

Soil crusts are layers which are more compact, hard and brittle when dry than underlaying material. The term has been used to describe layers of reduced permeability under intense rainfall or dense layers resulting from irrigation. Surface crusts can hinder agricultural crops by impeding seedling emergence or decreasing infiltration capacity (Bryan, 1973).

The consequences of soil crusts are sometimes quite severe. Several time replanting must be carried out due to failure of seedling to emerge through the surface crust. Another case, if soil crusts form, infiltration capacity is decreased, so it may generate a surface water layer during rainfall which can influence soil erosion and decrease water storage in the roots zone.

Formation of soil slaking and crusting are mainly attributed to the following factors:

a. Poor soil structure, particularly for soils those are under continuous cultivation.
b. Low organic matter.
c. Heavy rainfall.
d. Soil management with heavy machinery.
e. A critical clay/fine sand ratio.

For controlling soil slaking and crusting, various practices and soil treatments have been used:

a. On land covered by vegetation a large proportion of the raindrops are intercepted by the plants and loose most of their kinetic energy before reaching the soil surface.
b. Slaking and crusting of soils can be controlled by surface mulches, which protect the soils from the impact of raindrops.
c. For soils in humid regions the simple flocculation effects might be considered as the worst possible condition which can be improved by organic matter addition.
d. In arid regions the reclamation of dispersed soils by the use of gypsum, which establish the flocculated condition.

e. Certain artificial soil conditioners have been successfully used for preventing and reducing soil slaking and crusting by producing a stable aggregation.

The aim of this work is to study the changes in soil aggregate, bulk density and soil permeability rate as the indicators of soil crusts process through the use of chicken manure and chicken manure with PAM under intense rainfall with one day drainage process.

MATERIALS AND METHODS

Materials

Soil sample

Soil sample came from the upper 5 cm layer, taken off loamy sand soil texture class. Physical and chemical compositions of the soil sample are presented in Table 1.

Table 1. The physical and chemical compositions of soil sample

No	Kinds of analysis	Value	Explanation
1	Sand (%)	70.2	Loamy sand
2	Silt (%)	24.4	Texture class
3	Clay (%)	5.4	
4	pH – H_2O	5.27	
5	pH – KCl	4.03	
6	Organic matter (%)	1.62	
7	$CaCO_3$ (%)	0.00	
8	E 1/5 (mS. Cm^{-1})	0.049	
9	N – Total (mg N/100 g DS)	90	
10	NO_3^- - N (ppm)	3.8	
11	P – Total (mg/kg DS)	510	
12	$P_{ext.}$ (mg/kg DS)	68.8	
13	K – Total (mg/kg DS)	1000	
14	$K_{ext.}$ (mg/kg DS)	100	

Treatments of soil sample

Organic matter. Chicken manure was used as organic matter treatment doses. Physical and chemical compositions of the chicken manure are presented in Table 2.

Chicken manure treatments used in these experiments are :

T0 = original soil with 1.82% natural organic matter

T1 = soil with 0.2 % organic matter/chicken manure

T2 = soil with 0.8% organic matter/chicken manure

T3 = soil with 1.8% organic matter/chicken manure
T4 = soil with 3.0% organic matter/chicken manure
T5 = soil with 5.0% organic matter/chicken manure

All treatments were incubated for three weeks, at 27℃ temperature. Soil mouisture contents were kept at field capacity during the incubation.

Polyacrylamide (PAM). Soil conditioner used in the present work was an organic polymer solution of polyacrylamide (PAM). Physical properties of PAM are :

Viscosity	: 200 to 2000 cps at 25℃
Molecular weight	: 250.000 (normal range 200.000 to 1.000.000)
Concentration of Active material	: 16% by weight
Content of monomer	: less than 0.05%

In this study, PAM was applied on soil in a concentration of 2/1000 dry weight.

Table 2. The physical and chemical compositions of chicken manure

No	Kinds of analysis	Value
1	Fraction (% air dry):	
	Diameter (mm)	
	8 – 4.76	6
	4.76 – 2.83	11
	2.83 – 2.00	18
	2.00 – 1.00	29
	1.00 – 0.50	17
	0.50 – 0.297	8
2	Moisture (% oven dry weight)	13
3	Total N (%)	5.0
4	P_2O_5 (%)	3.0
5	K_2O (%)	1.5
6	CaO (%)	5.0
7	MgO (%)	2.0
8	SO_3 (%)	1.5

Methods

Soil preparation

Five replications were used for each treatment in these experiments.

Organic matter destruction. Organic matter was destructed by H_2O_2. The result of the destruction was checked by the measurement of the organic – Carbon with the Walkley and Black Method (Cottenie and Verloo, 1982).

Determination of field capacity. To determine which time at field capacity will be achieved, a soil sample was subjected to an evaporation under laboratory condition.

Determination of the aggregate stability. The dry and wet sieving were carried out according to the method described by De Leenheer and De Boodt (1967).

Approximately 500 g of air dry soil (diameter less than 8 mm) was sieved on a set of sieving with mesh widths of 8, 4.76, 2.83, and 2 mm. Shake gently by hand to devide these dry aggregates into the different fractions, without breaking the aggregates. Soil fraction less than 2 mm is discarded, and the fractions of 8 to 4.76, 4.76 to 2.83, and 2.83 to 2 mm were weighed and placed in nickel cups. The fractions were brought to field capacity and were incubated one night before wet sieving. The mean weight diameter of the dry and the wet stable aggregates, was calculated using the following formula:

$$\sum \left[\frac{\text{mass \% soil} \times \frac{\text{Greatest diameter} + \text{smallest diameter}}{2}}{100} \right]$$

The difference between the dry and wet mean weight diameter gives the instability index. The soil is easy to erode, if it has high instability index.

$$\text{Instability Index} = \frac{1}{\text{Stability Index}}$$

The Soil Stability Quotient = % Aggregation x Stability Index

Determination of soil bulk density. Soil bulk density was calculated as the ratio of the weight of oven-dry soil to the bulk volume of the soil (volume of soil particles plus pore spaces).

Raindrop impacts. Rainfall simulator utilizing nozzles operated under pressure has been developed, by means of which rain characteristics can be controlled with a fairly wide range. The controllable measurements are intensity, drop size distribution, and drop velocity distribution.

Air dry soil samples are put into rings with 8 cm diameter and 4 cm height. The weight of each soil sample is based on the bulk density of each treatment. The rainfall intensity was 42 mm per hour, and samples were placed under the rain for a period of 10 minutes.

Determination of water permeability of saturated soil. Water permeability of saturated soil was determined according to method described by Verplancke (1983). It can be calculated using following equation :

$$Kw = -\frac{Qw}{A.t} \times \frac{\Delta z}{\Delta \psi_h}$$

K_W = water permeability (cm/hour)
Q_W = quantity of water, that flow for each measurement (ml)
A = wide of soil surface
t = time (hour)
Δz = distance measured in vertical direction/thickness of soil (cm)
$\Delta \psi_h$ = difference in hydraulic potential between two points (cm)

RESULT AND DISCUSSION

Aggregation Percentage

Total amount of aggregates which is greater than 2 mm, is a measure of aggregation percentage and can easily be determined with a dry sieving. The aggregation percentage of the soil treated with organic matter and a mixture of organic matter with PAM is graphically presented in Figure 1.

From this results we can conclude that, the aggregation percentage of organic matter in combination with PAM is higher than that of organic matter, due to the more effectiveness of PAM to form aggregates. The more addition of organic matter to the soil seems to increase the aggregation percentage, however, no significant differences could be observed. The reason is probably that the incubation period was not sufficient in order to perform a reaction of organic matter with the soil (Khaled, 1982).

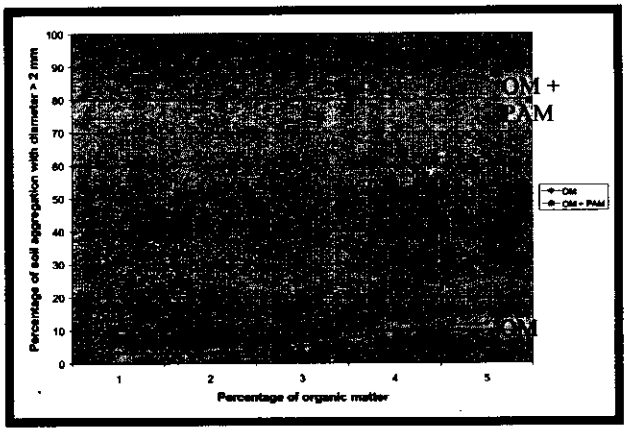

Figure 1. Changes in percentage of soil aggregation through the use of organic matter (OM), mixture of organic matter and PAM (OM + PAM)

Soil Stability Quotient

From Figure 2, it can be seen that, the stability quotients of organic matter in combination with PAM are higher than that of organic matter treatments, due to the more effectiveness of PAM in increasing the aggregate stability than that of by organic matter.

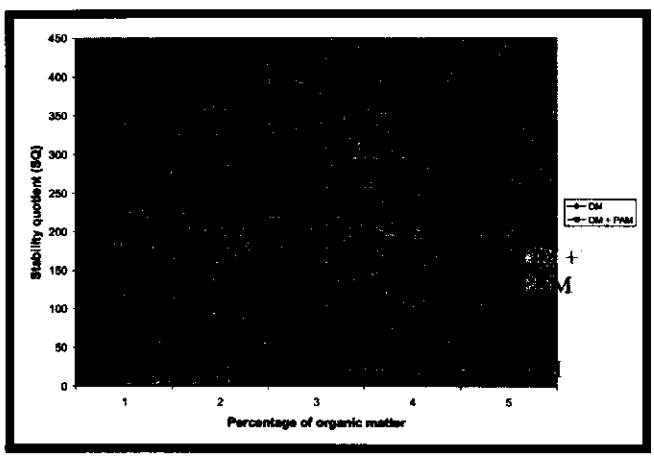

Figure 2. Changes in soil stability quotient through the use of organic matter (OM), mixture of organic matter and PAM (OM + PAM)

An increase of the stability quotient is established when PAM is added in combination with organic matter at a rate of 1.8%. However, the addition of higher amounts of organic matter decreases the stability quotient (Figure 2). The reason can be that PAM is partly adsorbed by the organic matter when

high amounts of organic matter are present. PAM is a long chain molecule, so that some links of molecules probably exist between the soil aggregates.

Bulk Density (BD)

Means of bulk densities of the treatments are shown in Figure 3. A lower bulk density is observed when organic matter is added in combination with PAM, which is also becase PAM is more effective to form aggregates with diameter bigger than two milimeter.

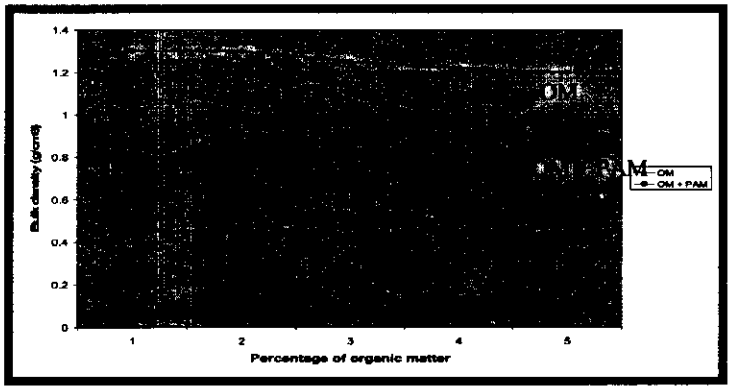

Figure 3. Changes in soil bulk density through the use of organic matter (OM), mixture of organic matter and PAM (OM + PAM)

Higher amounts of organic matter seems to increase the bulk density, due to the low particle density of organic matter and because of addition organic matter increasing of the pore spaces.

Permeability Rate

Figure 4 illustrates that the organic matter did not significantly influence the permeability rate.

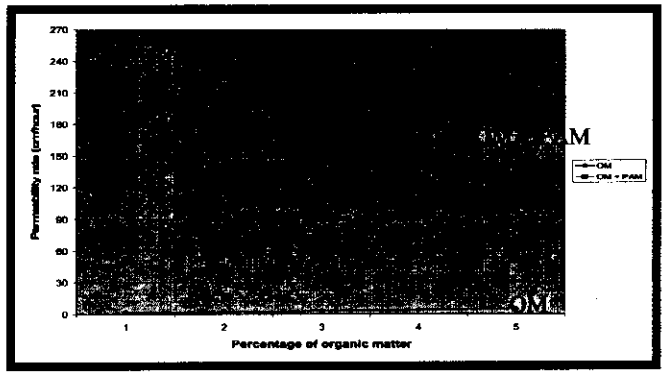

Figure 4. Changes in soil permeability rate through the use of organic matter (OM), mixture of organic matter and PAM (OM + PAM)

However, the combination of organic matter with PAM results in an increase on two percent of organic matter content and subsequent decrease of the permeability rate.

Hence, by referring to the two previous parameters, it can be concluded that the permeability rate pattern (Figure 4) is about the similar curve with that of the stability quotient (Figure 2). Consequently, the permeability rate of OM + PAM treatment is more rapid than OM treatment.

CONCLUSION

The preceding study and its supporting documentations support the conclusions that an incremental additions of organic matters into a soil will increase their aggregation percentage, soil stability, permeability rate of the soil which have been taken up immediately after the rainfall with one day drainage process. Moreover, their increments will decrease the bulk density of the soil which have been taken up after having a one day drainage process.

The combined incremental additions of the organic matter with PAM were found to be more effective than only an incremental additions of organic matters, in increasing the aggregation percentage, soil stability, permeability rate from the soil with one day drainage process, but another case in decreasing the bulk density from the soil with the same process.

For finding the best result of this experiment, all treatments should be incubated longer than three weeks duration.

REFERENCES

Bryan, R.B. 1973. Surface crusts formed under simulated rainfall on Canadian soils. Conferenza tenuta il 4 April, per conto del laboratorio per la chemica del Tereno del C.V.R.

Cottenie, A. and M. Verlbo. 1982. Soil chemistry. Rijks-universiteit Gent, ITC for Post Garduate Soil Scientists.

De Leenheer, L. and M. De Boodt. 1967. Aggregate stability determination by the change in mean weight diameter. In West-European methods for sc.' structure determination, add. by the West European working group on soil structure of the ISSC. Ghent, VI: 28.

Khaled, E.M.N. 1982. Influence of organic matter, iron and soil conditioners on soil physical properties. Thesis. Rijksuniv. Gent. ITC for Post Graduate Soil Scientist.

Verplancke, H. 1983. Soil physics. State Univ. Ghent, Belgium. Departement of Soil Physics.