EFFECT OF MOISTURE INCUBATION AND MANURE APPLICATIONS ON MECHANISM OF SOIL AGGREGATES STABILITY

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ABSTRACT

A research was conducted on a clay loam soil, to study the interactions of various parameters on soil aggregates stability. Typic Torrifuvent natural aggregates of topsoil were sieved throughout 8 mm sieve, mixed with three levels of manure material and incubated for three intervals under three levels of soil moisture content. The changes in aggregates stability at the end of each incubation period (7, 30 and 60 days) were determined by wet sieving method. Moisture incubation treatments with manure applications gave larger proportions of stable aggregates than that without manure applications. Under dry incubation, the type of manure added had little effect on soil stability. With saturation incubation, the manure applications revealed lower increase in proportions stability than did with other moisture treatments. Interaction effects between incubation, moisture and manure application treatments were significant. Soil aggregates with moisture or with manure become more stable under incubation intervals than controls, which may indicate differences in the binding mechanisms of the soil particles. The changes in stability of soil moisture treatments suggested mechanical and physical rather than microbiological effects.

INTRODUCTION

Most of soils have physical problems which require profile modification to improve crop production. Several studies have addressed the role of micro- organisms, seasonal fluctuations and some other factors that occur in aggregation [1,2, 3, 4]. Soil moisture condition, clay content and organic material are important factors affected soil aggregate stability [5].

The experimental results of Perfect et.al. [6] revealed that moisture in the soil is the key variable influencing dispersible clay and wet - aggregate stability in soil profile. The improvement in soil aggregate stability was frequently associated with increasing organic matter decomposition [7].However, owing to the great diversity of soil types and treatments, it is often difficult to interoperate the mechanism of soil aggregates formation results or to compare them with other workers. Most researchers can not with certainty simulate the conditions leading to the differences in formation of natural aggregates stability under a variety conditions [8].

This raise the need for an investigation on the interactions of various parameters that may exert temporal influences on soil structure such as soil incubation, moisture condition and organic materials.

MATERIALS AND METHODS

Surface soil (0-15cm) of clay loam (caly 395, Silt 375 and Sand 230 gm. Kg^{-1}) typic Torrifuvent of Abu- Al- Khassib in Basrah Govern, Iraq, characterized by regular management, was used for moisture incubation studies on natural soil aggregates. The soil was air dried and sieved throughout 8 mm sieve and mixed with organic materials (fresh manure material) in order to obtain three levels: 0, 2 and 4% w/w of dry soil namely OM_0, OM_1 and OM_2, respectively. One hundred fifty grams of the soil portions were placed in each of eighty one plastic containers (250 cm^3 volume) in order to obtain three organic material levels, three moisture levels and three incubation periods with three replicates.

The water was added to the soil to obtain three moisture levels: air dry (M_1), field capacity (M_2) and saturation (M_3). The plastic containers were then incubated aerobically in an incubator atmosphere of 30 C° for 7 days (C_1), 30 days (C_2) and 60 days (C_3). Containers were weighted daily and water added to maintain the specific water content. At the end of each incubation interval, samples were taken and soil aggregates stability determined by wet sieving method described by Black et. al. [9] . Sieves set of 0.25, 0.5, 2 and 4mm mesh were used, and fractions greater than 0.25, 0.5, 2 and 4mm diameter dried and weighted for the calculations of soil proportion aggregates stability and total aggregates stability percentages.

RESULTS AND DISCUSSION

Statistically, at each moisture treatment, the differences in incubation, manure applications, proportions of water stable aggregates and the interactions within the treatments were highly significant (Table 1). Aggregate proportions > 0.25 and > 0.50 diams., gave the greater percentages than > 2 and > 4 mm diams. (29.37, 28.39, 7.45 and 7.43%, respectively). Experimental analysis of the influence of organic material and micro-organisms on soil structure has confined that the formation of small clusters of soil particles are resistant to the disintegrating action of water [5]. Aerobic incubation with 4% OM of dry and field capacity moisture conditions gave larger proportions of water-stable aggregates greater than 0.25 mm diams. (19.89 and 29.37%, respectively), than did incubation with 0% or 2% OM (15.55, 15.75, 15.95 and 16.02%, respectively). Stability of soil aggregate proportions were usually the lowest under anaerobic incubation (saturation condition). The manure applications had little effect on the proportions after anaerobic incubation.

However, significant differences were found within the treatments (i.e. RLSD values were 6.5, 3.0 and 3.3 for incubation, manure and moisture treatments, respectively).

The largest differences in total aggregates stability being 14.08% among M_2 and M_3; 13.06% among C_1 and C_2 and 9.07% among OM_0 and OM_2 treatments.

Table 1: Variance analysis (F values) of aggregates stability data for dependent variables. All F values are significant at P= 0.001

Source	M_1	M_2	M_3
Incubation (A)	713.97 j	110852.98	4389.08
Manure (B)	300.65	37359.79	11381.21
Aggr. Proportion (C)	41056.23	557973.69	586161.46
AXB	11.42	14689.05	1027.03
AXC	158. 25	11818.26	1458.25
BXC	16.51	784. 08	1225.54
AXBXC	9.82	1166.34	274.34
R squared	0.99	1.00	1.00

Dry soil incubation (M_1) with manure gave a small rise in amount of water stable aggregates proportions (Figure 1). The largest value was with 4% OM after 30 days of incubation which yielded about 20 and 14% of stable aggregates for >0.25 and >0.50 mm diams., respectively, while, only 4 and 0.3% for >2 and >4 mm diams., respectively. The significant RLSD values for incubation, manure and aggregate proportions were 0.20, 0.40 and 1.95, respectively. The results for treated and untreated soils were similar, the general pattern being an increase in stability after incubation and tended to decrease in proportions stability after an initial increase. This results indicating that micro - organisms were not primarily responsible for this changes, similar results were found by Lynch and Bragg [10] for the effect of organic material decomposition on soil aggregates stability.

Incubation for 30 and 60 days gave larger proportions of water -stable aggregates than the samples incubated for 7 days only. Results of proportions >0.25 and >0.50 mm diams., for all incubation periods were almost identical in trend, but stabilities were usually higher than those of >2 and > 4mm diams., after the corresponding incubations. The possible explanation is provided by Tisdall and Oades [11], meaning that larger aggregates are made up of smaller aggregates, and thus communities from larger aggregates are the sum of communities from smaller aggregates.

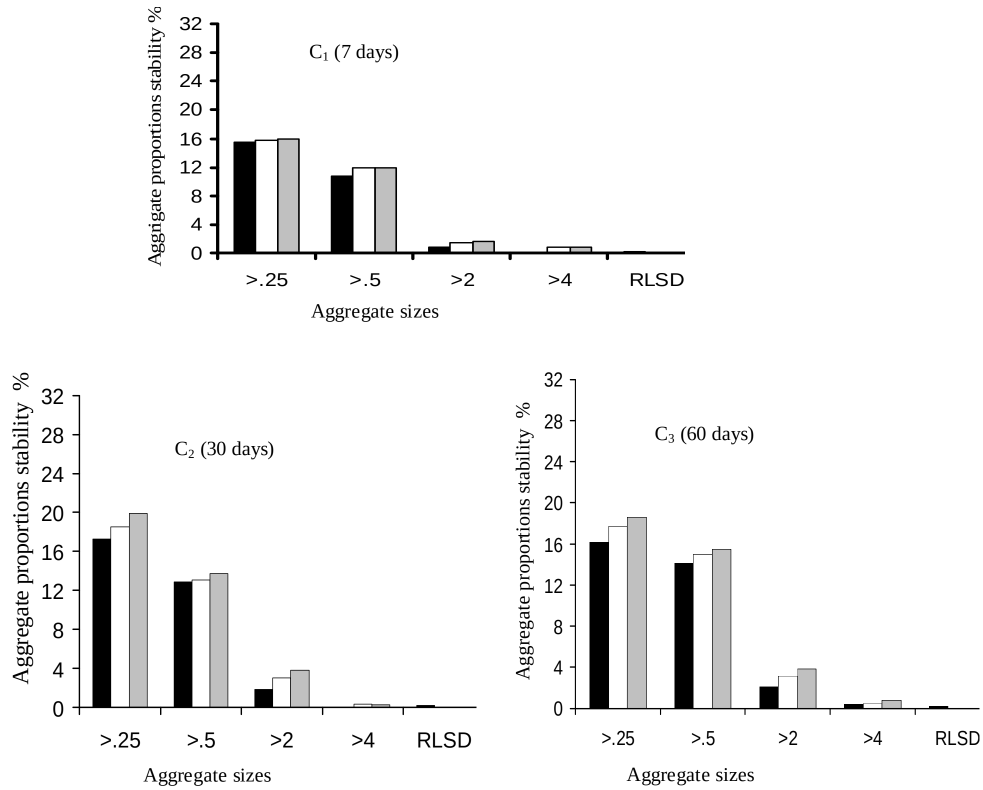

Figure 1. Stability % of soil aggregate proportions (AS %) for air dry soil (M_1) incubation treatment. RLSD represents the revise least significant differences.

OM_0 (0 %), OM_1 (2 %) , OM_2 (4 %).

For soil incubated at field capacity (M_2), the incubation period for 30 days gave greater proportions stability with all manure applications than did 7 days or 60 days incubation periods (Figure 2). The statistical analysis of F values indicated significant differences between treatments (Table 1). During incubation, however, proportions aggregate stability increased with increase manure applications, while the untreated control soil maintained their original low level of stability. The most effective treatment was 4% OM which produced by the end of the 30 days, aggregates which could not be disintegrated by wet sieving technique. The polysaccharide was appeared to be the dominant elements of aggregates formation [7]. Moreover, analysis of aggregates after 60 days incubation period revealed only a small increase in values.

In general, aggregate proportions > 0.25 and > 0.50 mm diams., developed greatest stability values in all incubation periods, while the >2 and >4 mm diams., resulted lowest values. Examination of the results showed that there was an increase in variations with increasing time of incubation and manure applications. On the other hand, natural aggregates of untreated control soil showed less variation in stability. Significant differences were developed between treatments (i.e RLSD values were 2.90, 1.05 and 1.30 for incubation, manure and aggregate proportions, respectively). Schutter and Dick [4] have reported that carbohydrate present in manure residuals is likely to have favored polysaccharide formations for binding soil particles together and so increasing proportion stability.

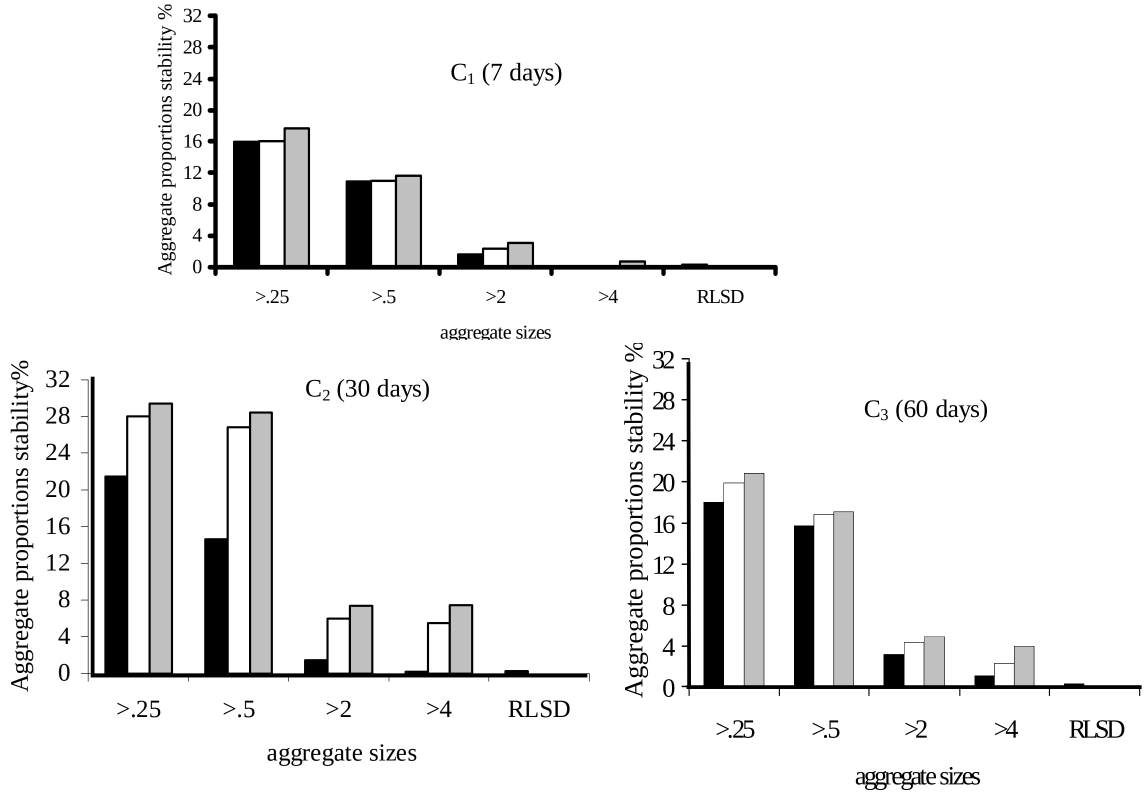

Figure 2: Stability % of soil aggregate proportions (AS%) for moisture incubation at field capacity treatment (M_2). RLSD represents the revise least significant differences.

■ OM_0 (0 %), □ OM_1 (2 %), ▒ OM_2 (4 %).

Anaerobic incubation at saturation with manure applications gave little improvement in soil aggregate proportions stability over the incubation periods (Figure 3.) Highly significant differences among the treatments were revealed in Table 1. The effects of the individual treatment were examined in more detail by calculating their RLSD values. The values were significant for incubation periods (0.08), manure applications (0.73) and aggregate proportions (0.73). F value showed substantial and highly significant differences in stability of aggregate proportions. This can be attributed to the lower value for aggregates stability of >2 and >4 mm diams., were found at all incubation periods than for the proportions of > 0.2 5 and > 0. 50 mm diams., This results suggested that it might be aggregate sizes >2 and > 4 mm diams., lost stability during incubation and broken up to varying extents on wet sieving. Tisdall and Oades [11] indicated that the properties of aggregates would appear to depend primarily upon the nature and distribution of the cementing materials. Anaerobic incubation (at saturation) results revealed that soil samples were always less stable to wet sieving than the corresponding samples that aerobically incubated at dry and field capacity treatments. This relationship is in agreement with the results of Perfect et.al. [12] whose found a strong relationship between soil moisture content within the different treatments and rates of structural improvement.

In general, when control soil (untreated soil) was misted and incubated for one week before wet sieving, an increase in proportions of water stable aggregates was recorded, but had marked increase when it incubated for one month especially at field capacity moisture incubation treatment. Perfect et.al. [12] revealed that moisture is the dominant variable affecting soil structure. These changes in the soil aggregates suggested that it might, at least in part, have physical rather than microbiological effects [13]. The finding may reflect a rather mechanical binding of the soil particles [14]. However, comparison the results for different moisture treatments indicated that during aerobic incubation with water, there was marked change in the stability of proportion aggregates, > 0.25 and > 0.50 mm diams. The results were lower for anaerobic incubation compared with the aerobic incubation. Slow and small changes in stability are characteristic of aggregates > 2 and >4 mm diams, incubated with water. However, aerobic incubation with manure gave more improvement in proportions of aggregate stability than did with water alone. It seems more probable that polysaccharides of microbial origin are the main organic components involved in the formation of stable aggregates and there is considerable evidence in supporting of this view [7].

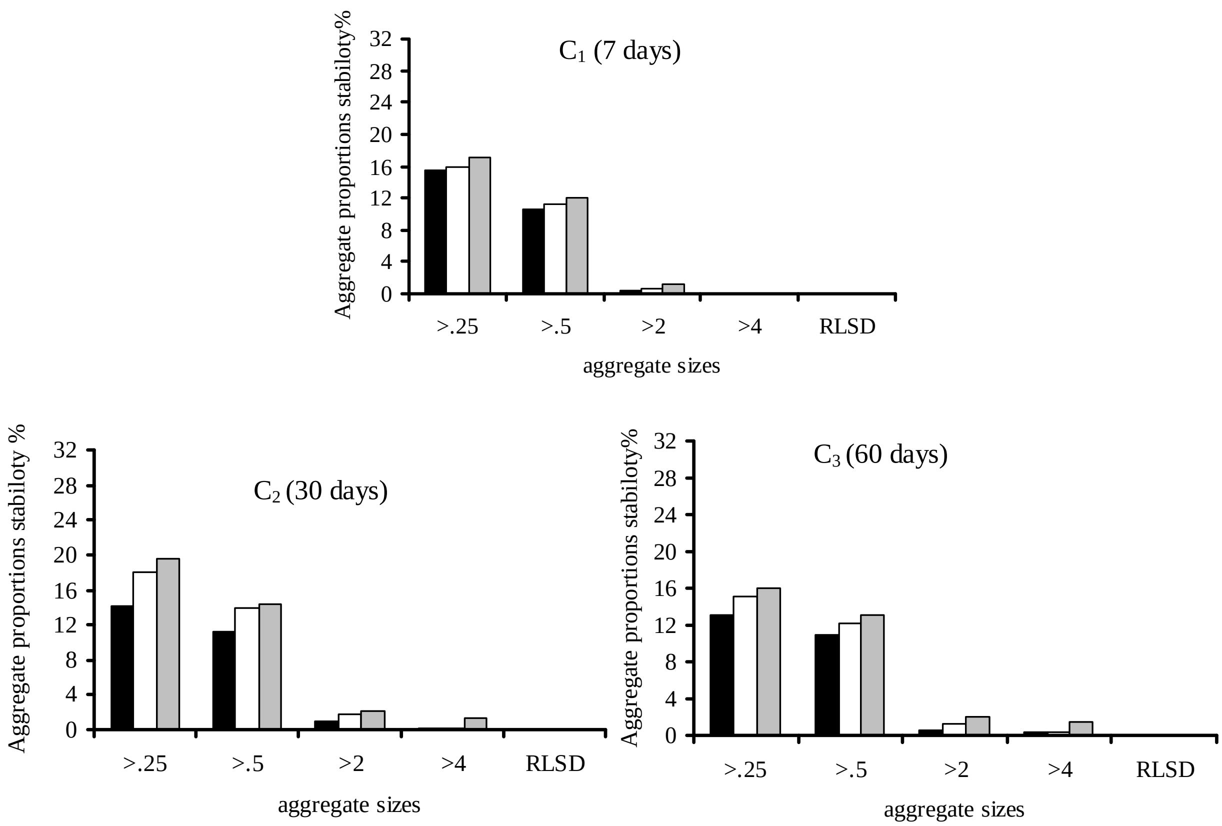

Figure 3. Stability % of soil aggregate proportions (AS%) for moisture incubation at Saturation treatment (M_3). RLSD represents the revise least significant differences.

■ OM_0 (0 %), □ OM_1 (2 %), ▒ OM_2 (4 %).

soil incubation and manure applications at different moisture regimes (Figure 4, 5 and 6). Highly significant differences were denoted in F values for all dependent variables and their interactions (Table 2).

Table 2: Analysis of variance (F values) of total aggregate stability values for dependent variables. All F values are significant at P = 0.001

Source	F value
Incubation (A)	61732.98
Manure (B)	33802.83
Moisture (C)	77934.85
AXB	6761.20
AXC	24410.81
BXC	4351.00
AXBXC	3652.47

With each moisture incubation treatment, the stability percentages always increased as manure application increase (Figure 4). Aerobic incubation treatment (M_2) indicated larger increase especially at 30 days incubation period compared with the other moisture treatments (M_2 and M_3). The lowest results were recorded at anaerobic incubation treatment (M_3). Jastrow [15] concluded that aggregation is influenced by the mineral constituents of the soil, notably clay, but organic matter is considered to be most important. Decomposition of organic matter regularly leads to increased aggregation in the soils [16].

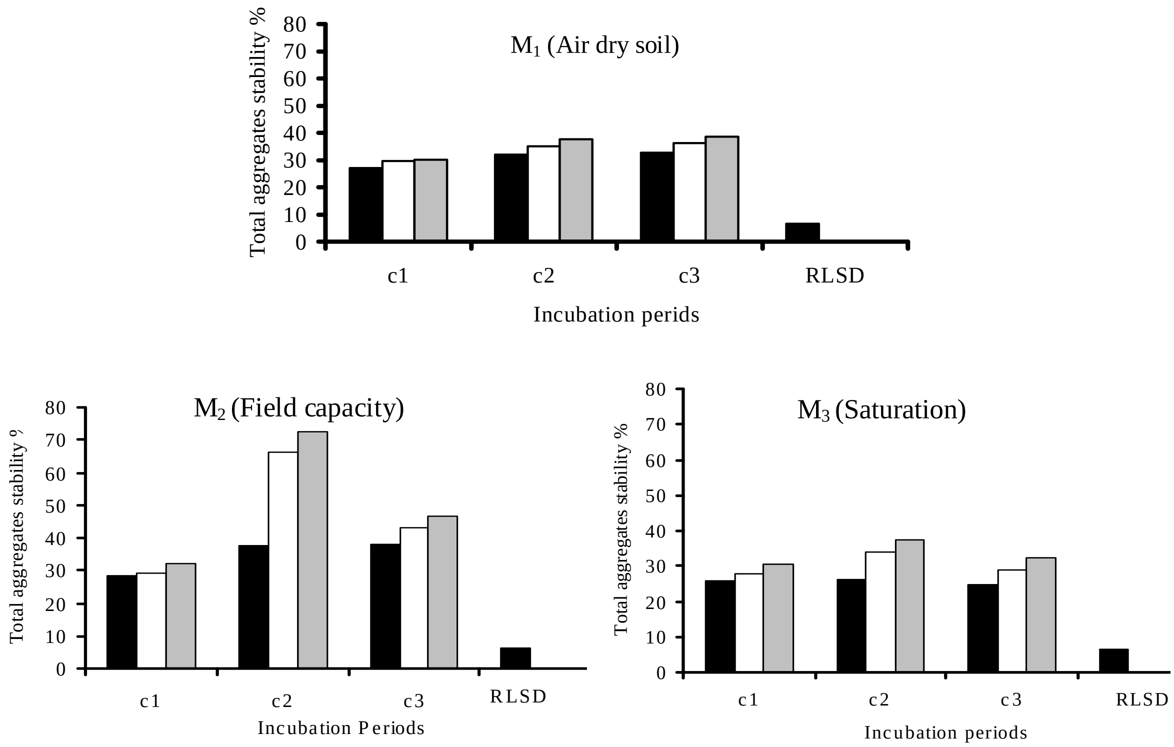

Figure 4. Soil Total aggregates Stability % (TAS%) for moisture incubation treatments. RLSD represents the revise least significant differences.

OM_0 (0 %), OM_1 (2 %), OM_2 (4 %).

The data revealed significant and considerable variation among manure treatments (Table2). There was an increase in variation with increasing manure and time of incubation (Figure 5). The reason for this systematic increase in variations presumably reside in difference between treatments in respect of aeration and moisture content of soil. During incubation, however, moisture levels have little increased in aggregates stability with untreated (OM_0), while the treatments (OM_1 and OM_2) denoted remarkable increase in stability compared with the original level of stability. In all cases, the field capacity treatment at 60 days incubation period gave the highest values, while the saturated treatment gave the lowest in all cases. This finding is similar to that of Perfect et. al. [12] where, their results of structural stability of field soil within cropping treatments were decreased with increasing soil moisture content.

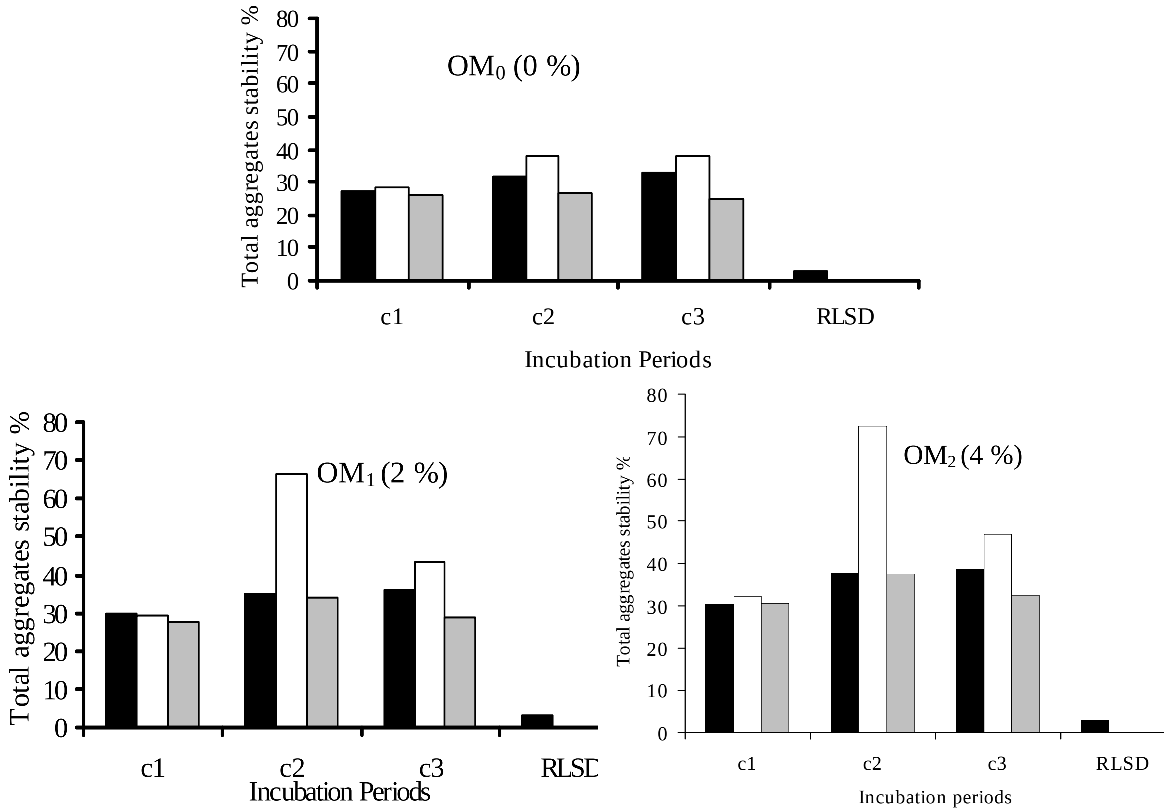

Figure 5. Soil Total aggregates Stability % (TAS%) for manure application treatments. RLSD represents the revise least significant differences.

■ M_1 (air dry soil) □ M_2 (Field capacity), ▒ M_3 (Saturation).

It can be seen that the response to the addition of manure residuals at each incubation period produced significant effect with all moisture treatments (Table 2). For most moisture incubation treatments, lower values for stabilities were found at 60 days than at 30 days incubation period, whereas the lowest values occurred at 7 days incubation period (Figure 6). Moreover, there are clear increase in stability values as manure application increase but aerobic moisture incubation (M_2) at 30 days period and manure level OM_1 and OM_2 produced substantial and highly significant increase in stability. A likely explanation of this is that the provision of extra residuals enabled micro-organisms to decompose manure or carbohydrate compounds that have favored polysaccharide formation for binding soil particles together, and so increased crumb stability [17].

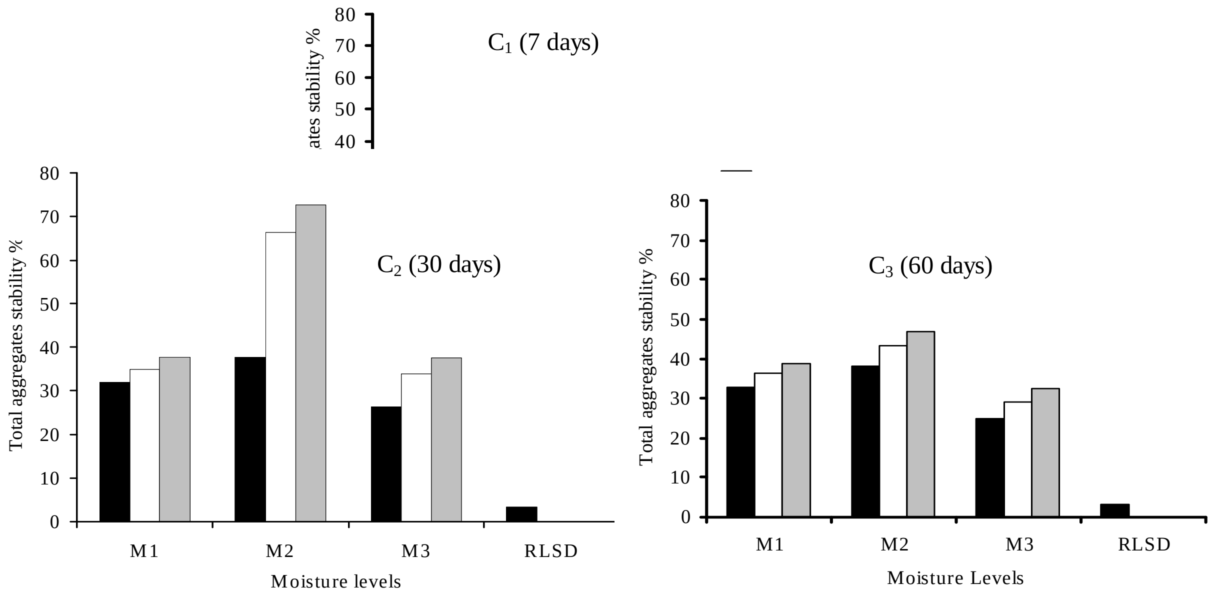

Figure 6. Soil Total aggregates Stability % (TAS%) for incubation periods. RLSD represents the revise least significant differences.

■ OM_0 (0 %), □ OM_1 (2 %) and ▨ OM_2 (4 %).

Comparisons the total mean values for different treatments were examined by means of the revise least significant differences, and results of the analysis are shown in Table 3. It can be seen that variations between treatments were high and hence all differences can be expected to be significant. Such results indicated that soil aggregates stability can be influenced in unpredictable ways, because of the complex interactions among environmental factors, substrate quality, and time that occur in mechanism of aggregate formations [4].

Table 3 The revise least significant differences (RLSD) values between means of different treatments.

Treatment	Means of the total values		
	Incubation	Moisture	Organic material
1	29.07 b	33.28 b	30.38 c
2	42.13 a	43.89 a	36.75 b
3	35.77 a	29.81 c	39. 85 a
RLSD	6.50	3.30	3.00

The results highlighted , the physical and mechanical influences of aerobic and anaerobic incubation conditions with various manure residuals levels on the development of soil aggregate stability. However, owing to the great diversity of the soil types and the micro - organisms in them it is often difficult to interpret the results or to compare them with those of other workers. The most reasonable objective for further work would seem to be to identify those aggregate stabilizing mechanisms that are microbial and to distinguish them from those that are physical and mechanical or chemical under a wide range of environmental conditions. Unfortunately in all researches the functions describing the change in soil structure with time cannot be obtained, also, the initial structural conditions history of the soil is unknown. Furthermore , the mechanisms responsible for long - term changes and seasonal variations in soil structure under different soil conditions and crop production are incompletely understood.

REFERENCES

1. Harris, R. F. ; Chester, G. and Alien, O.N. (1966). Dynamics of soil aggregation. Advance in Agronomy. 18: 107 - 169.
2. Hamblin, A.P. (1977). Structural features of aggregates in some east Anglian silt soils. J. Soil Sci. 28:23-28.
3. Coote, D.R.; Malcolm- Me Govern. C.A.; Wall G. J.; Dickinson, W.T. and Rudra, R.P. (1988). Seasonal variation of credibility indices based upon shear strength and aggregate stability in some Ontario soils. Can. J. Soil Sci. 68: 405 - 424.
4. Schutter, M.E. and Dick, R.P. (2002). Microbial community profiles and activities among aggregates of winter fallow and cover —cropped soil. Soil Sci. Soc. Am. J. 66:142-153.
5. Oades, J.M. (1984). Soil organic matter and structural stability. Mechanisms and implications for management. Plant and soil.76 : 319 -337.
6. Perfect, E.; Kay, B.D.; Van Loon, W.K.P.; Sheard, R.W. and Pojasok, T. (1990a). Factors influencing soil structural stability within a growing season. Soil sci. soc. Am. J. 54: 173-179.
7. Angers, D. A. and Giroux, M. (1996). Recently deposited organic matter in soil water - stable aggregates. Soil Sci. Soc. Am. J. 60: 1547 - 1551.
8. Six, J.; Elliot, E.T. and Paustian, K. (1999). Aggregate and soil organic matter dynamics under conventional and no- tillage system. Soil sci-soc. Am. J. 63: 1350 - 1358.
9. Black, C.A.; Evans, D.D.; Wilter,L.L.; Ensminger, L.E. and Clark, E.E. (1982). Method of soil analysis. Part 1 and 2. Agronomy series. No. 9, Am. Soc. Agron.
10. Lynch, J.M. and Bragg, E. (1985). Micro-organisms and soil aggregate stability. Advances in soil Sci. 2: 133-171.
11. Tisdall, J. M.; and Oades, J.M. (1982). Organic matter and water stable aggregates in soils. J. Soil sci. 33: 141-163.
12. Perfect, E.; Kay, B.D.; Van Loon, W. K. P. ; Sheard, R. W. and Pojasok, T. (1990b). Rates of change in soil structural stability under forages and corn. Soil Sci. Soc. Am. J. 54 : 179-186.
13. Needelman, B.A.; Wander, M,M.; Bollero G.A.; Boast. C. W.; Sims, G.K. and Bullock , D.G. (1999). Interaction of tillage and soil texture biologically active soil organic matter in Illinois. Soil Sci. Soc. Am. J 63: 1326-1334.
14. Zobeck, T. M. and Popham, T.W. (1990). Dry aggregate size distribution of sandy soils as influenced by tillage and precipitation. Soil sci. soc. Am. J. 54: 198-204.

15. Jastrow, J.D. (1996). Soil aggregate formation and the accrual of particulate and mineral - associated organic matter. Soil Biol. and Biochem. 28: 665 - 676.
16. Griffiths, E. (1965). Micro- organisms and soil structure. Biol. Rev. 40:129-142.
17. Aoyama, M; Angers, D.A.; N[f] dayegamiye, A. and Bissonnette, N. (2000). Metabolism of 13 C- Labeled glucose in aggregates soils with manure application. Soil Biol. Biochem. 32:295- 300.

تأثير الحضن الرطوبي والإضافات العضوية الحيوانية على ميكانيكية ثباتية مجاميع التربة

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الخلاصة

أجري البحث على تربة مزيجيه طينية نوع Typic Torrifuvent لدراسة تداخلات عوامل مختلفة على ثباتية مجاميع التربة. نخلت مجاميع طبيعية لتربة سطحية من خلال منخل سعة فتحاته 8 ملم، خلطت مع ثلاثة مستويات من المادة العضوية الحيوانية وحضنت لثلاث فترات تحت ثلاث مستويات من المحتوى الرطوبي للتربة. قدرت التغيرات الحاصلة لثباتية مجاميع التربة في نهاية كل فترة حضن (7، 30 و 60 يوم) بطريقة النخل الرطب. اعطت معاملات الحضن الرطوبي مع المخلفات العضوية الحيوانية ثباتية عالية لأحجام المجاميع مقارنة بالمعاملات غير المعاملة بالمخلفات العضوية. عند الحضن الجاف فان نوع المخلفات العضوية الحيوانية المضافة أظهرت تأثيراً قليل على ثباتية مجاميع التربة. في الحضن تحت ظروف التربة المشبعة فإن الإضافات العضوية الحيوانية أعطت أوطأ زيادة في ثباتية الأحجام مقارنة مع المعاملات الرطوبية الأخرى. تأثيرات التداخل بين معاملات الحضن والمستويات الرطوبية والإضافات العضوية الحيوانية كانت جميعها معنوية. أصبحت مجاميع التربة بوجود الرطوبة والمخلفات العضوية أكثر ثباتية تحت فترات الحضن المختلفة مقارنة بمعاملة المقارنة، والتي ربما تشير إلى اختلافات في ميكانيكية ربط دقائق التربة مع بعضها بشكل مجاميع. التغيرات الحاصلة في الثباتية لمعاملات التربة الرطوبية تشير إلى تأثيرات فيزيائية ميكانيكية أكثر منها مايكروبية إحيائية.