

EFFECT OF ADDING ORGANIC MATERIAL ON AGGREGATION IN NONCALCIC BROWN SOILS IN SRI LANKA

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ABSTRACT

Noncalcic brown soils are coarse textured and have a comparatively lower productivity than other soils present in Sri Lanka. It contains fairly low amounts of clay and organic matter. Due to these factors the soil has a weakly aggregated structure or remains single grained. An experiment was conducted during the seasons of *maha* 1997/1998 and *yala* 1998 to explore the possibility to increase the aggregation of this soil by repeated amelioration using locally available organic materials such as Farm Waste Compost (FWC) and Rice Straw (RS). Incorporation of RS (at 10 t/ha) and FWC (at 50 t/ha) in to the top layer (0-0.15m) of soil has increased the organic matter content of the soil. Amelioration of FWC has increased the aggregation of Noncalcic brown soils and the stability of such aggregates. The effects were visible even in soil layer just below the incorporation. Repeated amelioration has shown the possibility of sustaining the effects for longer period.

KEY WORDS: Aggregation, Noncalcic brown soils, Organic material

INTRODUCTION

Sri Lanka has soil diversity through out the island that varies from sandy soils to highly organic clay soils. Approximately one third of the area in the dry zone of Sri Lanka comprise of sandy soils. One of the important factors of these soils is that they are weak in structure. Aggregation of soil particles is always favourable in development of better soil structure resulting in high physical fertility. Martin *et al.*, (1955) defined a soil aggregate as a "naturally occurring cluster or group of soil particles in which the forces holding the particle together are much stronger than the forces between adjacent aggregates". Aggregation is a process where the primary particles of soil are brought together by different forces. Noncalcic brown soils in Sri Lanka, which is also known as Haplustalfs are characterised as coarse textured soils with low organic matter content. Specially, topsoil is low in aggregation or if there is any aggregation, the aggregates are less stable than the aggregates present in clay rich soils. This soil is found in a wide area in the northern dry zone of Sri Lanka and due to its low structural stability associated with undesirable characters, productivity is low compared to other soils in the area (Panabokke, 1996).

A method to increase the productivity of such soils is adding organic waste or waste products, which would increase the organic matter content of the soil, thereby increasing the aggregation and other desirable characters. Farm

Waste Compost (FWC) and Rice Straw (RS) are locally available and the changes made due to amelioration by these materials were measured to identify the role of amelioration in Noncalcic brown soils.

MATERIALS AND METHODS

The experiment was conducted at Regional Agricultural Research and Development Centre, Aralaganwila, during the seasons of 1997/1998 *maha* and 1998 *yala*. Average annual rainfall in the region is 2000 mm. Average temperature during April to September is around 32⁰ C and in October to March is around 29⁰ C.

A location was selected with imperfectly drained Noncalcic brown soils and organic ameliorations were done once in 4 months interval for a period of 8 months. FWC was used at 50 t/ha as mulch and incorporated to 0.15 m of the topsoil at the beginning of the experiment whereas RS was incorporated at 10 t/ha. After four months from the initial soil treatment similar quantities of RS and FWC were applied for previously ameliorated plots. Former mulching treatment was not continued after 4 months, instead new FWC incorporation was done. Soil samples were taken at the depth of 0 - 0.15 m and 0.15 - 0.3 m, in different treatments at one month, 4 months and 8 months after amelioration. Samples were used to determine the soil organic matter and the Mean Weight Diameter (MWD) of aggregates present in different treatments. Many investigators have preferred the use of the stability of aggregates as an index of soil structure instead of aggregate size distribution in the field (Kemper and Rosenau, 1986).

Mean weight diameter

Samples were removed from each soil treatment using an edge spade so as to minimise aggregate breakdown (Kemper and Rosenau, 1986). These were collected in large aluminium trays to avoid any crushing of sample by bagging or any other procedures. Samples were air dried and sieved using a rotary shaker consisting of a nest of sieves with openings of 5, 3, 2, 1, 0.5 and 0.25 mm for 5 minutes at an oscillation of 150 cycles per minute (Lysles *et al.*, 1970). The aggregates remaining on each sieve were weighed and expressed on a dry weight basis. Three replicates were used for each treatment. The data were used to calculate mean weight diameter. Mean

weight diameter (MWD) was obtained as proposed by Van Bavel (1949) using the following equation:

$$\text{MWD} = \sum_{i=1}^n X_i W_i$$

Where;

X_i is the mean diameter of i^{th} size fraction,

W_i is the aggregates retained on i^{th} sieve as a fraction of total sample and the summation is carried out to cover all n fractions.

Wet aggregate stability

The wet aggregate stability was determined using single sieve technique. The sieve used had an opening of 0.26 mm in diameter. Ten grams of 1 or 2 mm soil aggregates were pre-wetted using a wetting chamber and a vaporiser to prevent any pre-treatment effect (Kemper and Rosenau, 1986). These samples were then sieved in water at a frequency of 35 cycles per minute with a stroke length of 130 mm. Sieves were removed at different time intervals up to 16 minutes and the amount remaining on the sieve was expressed as a percentage of initial sample on dry weight basis.

Soil organic matter

Soil organic matter content was determined using the Walkley-Black method.

Soil organic matter

Samples taken at one month after amelioration showed an increase in organic matter content for all ameliorated treatments. Out of those, only the FWC incorporation treatment showed significantly higher ($p \leq 0.05$) organic matter content than bare soil. Samples taken just before the second amelioration showed that the incorporation plots had significantly higher ($p \leq 0.05$) organic matter content over the other plots. All of the treatments showed slight decrease in the organic matter content from the measurements taken at one month. At 8 months, all the ameliorated treatments showed significantly higher ($p \leq 0.05$) organic matter content than bare soil. In general, it was observed that both FWC and RS incorporation showed increase of organic matter content of the soil over time (figure 1).

Legend of the graphs used in this paper

BS - bare soil

C-M - Mulching with FWC at 50 t. ha⁻¹

C-In - Incorporation of FWC at 50 t. ha⁻¹

RS-In - Incorporation of rice straw at 10 t. ha⁻¹

RESULTS AND DISCUSSION

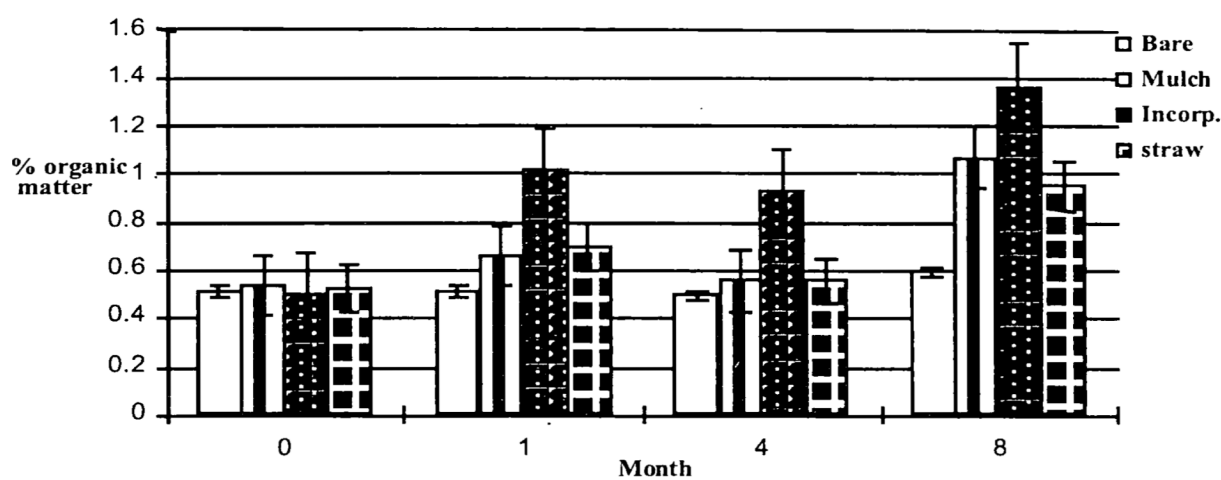


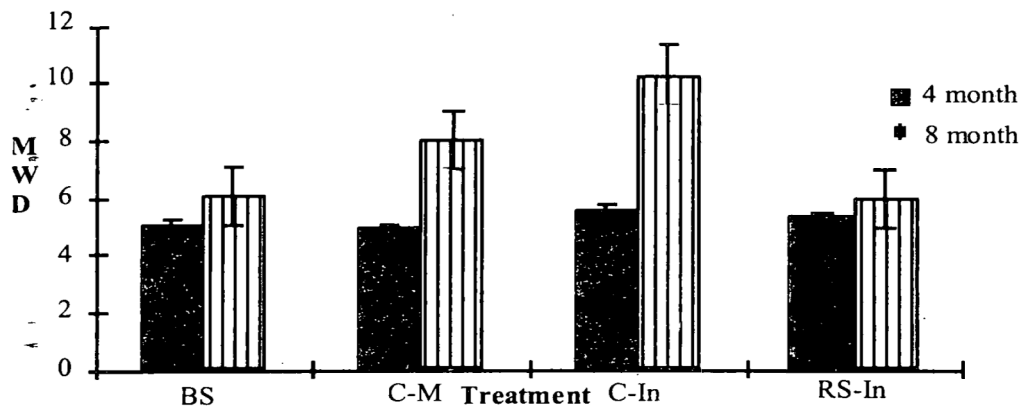
Figure 1. Change of soil organic matter content with time in a Noncalciic Brown soil.

Mean Weight Diameter (MWD)

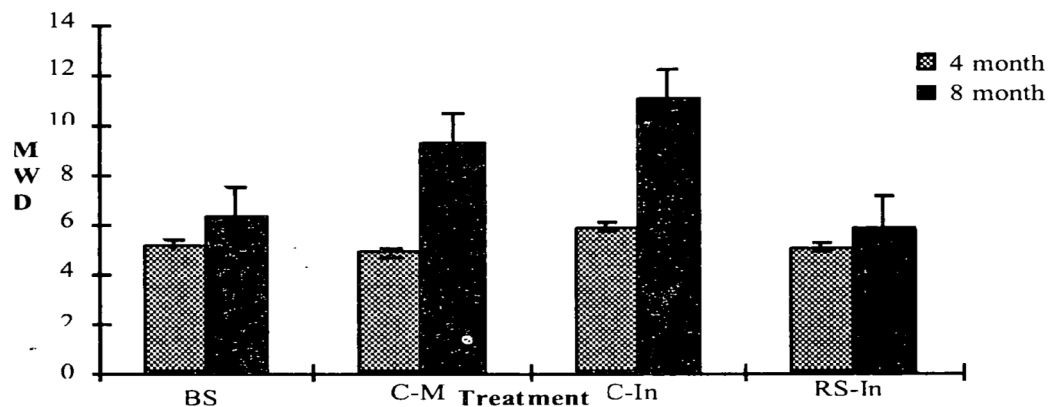
The MWD was calculated for samples taken at 4 months and 8 months, after dry sieving of soils from different treatments. At four months, according to the samples taken at 0 - 0.15 m depth, both incorporation of FWC and RS has significantly increased ($p \leq 0.05$) the MWD of aggregates present in this Noncalciic brown soil. However, there was no significant difference observed ($p \leq 0.05$) in MWD between the two incorporation treatments. At 0.15 - 0.3 m depth, the FWC incorporation treatments showed significantly higher ($p \leq 0.05$) MWD than the other treatments (figure 2a).

At 8 months (after two ameliorations) in 0 - 0.15 m depth, amelioration with FWC treatments showed higher MWD values when compared to values for bare soil and rice straw incorporation treatments. The MWD of the FWC incorporation treatment (where FWC was incorporated twice) showed a significantly higher ($p \leq 0.05$) value than all the other treatments. Even though the MWD value is not significantly higher ($p \leq 0.05$) in the FWC mulching

treatment (mulching + incorporation at 4 month), it shows a better value than the value obtained for rice straw incorporation treatment (figure 2b). MWD values obtained for the samples taken from 0.15 - 0.3 m depth at 8 months, showed both mulching and incorporation of FWC treatments produces significantly higher ($p \leq 0.05$) MWD values than other treatments.



(a) 0 - 0.15 m depth

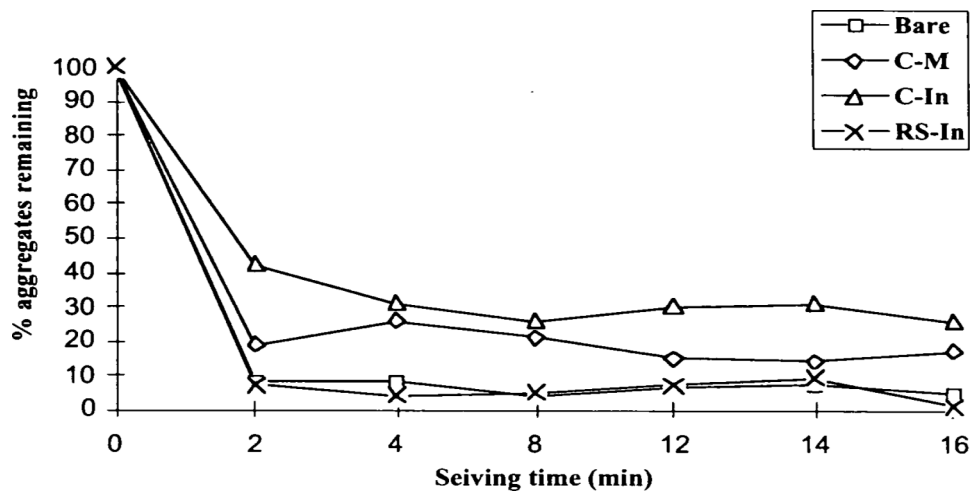


(b) 0.15 - 0.3 m depth

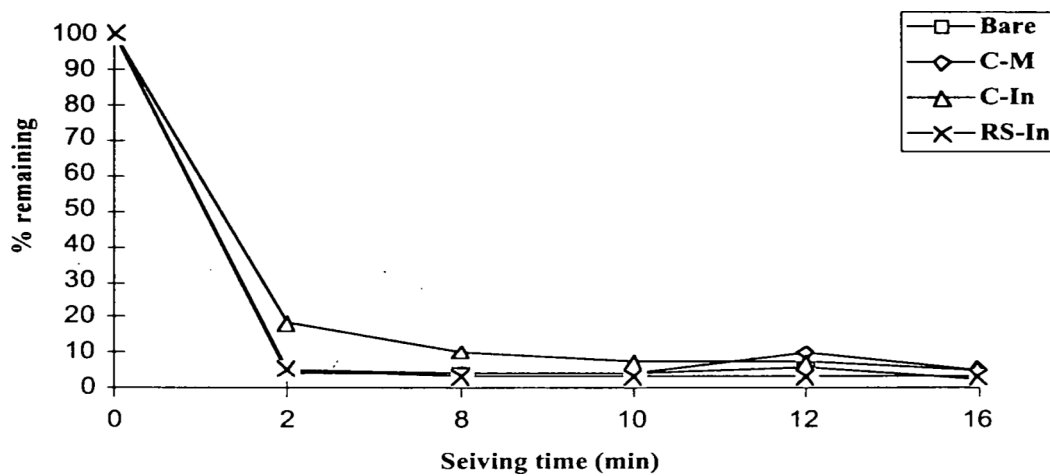
Figure 2. Mean weight diameter (MWD) of soil aggregates present at different depths in a Noncalic brown soil.

Wet aggregate stability

Kemper and Rosenau (1986) documented that wet aggregate stability determined by a single sieve method was well correlated with the stability of aggregates in the field. The results obtained for the wet aggregate stability measurements for all four treatments for 0 - 0.15 m depth of soil are shown in figure 3 (a).

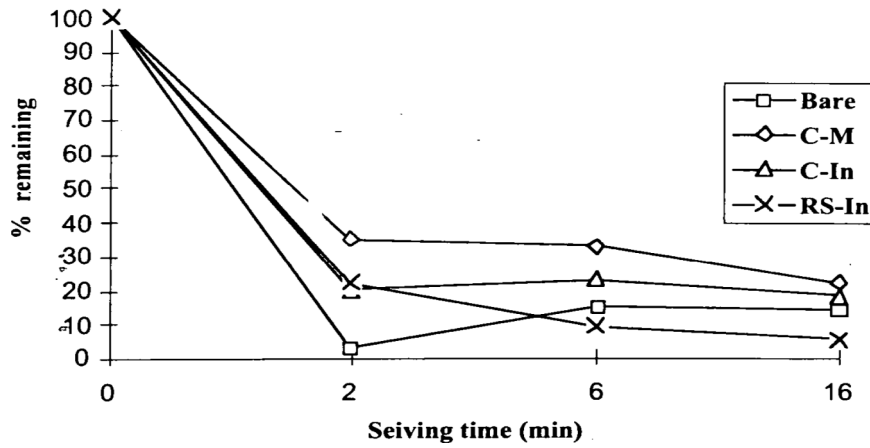


(a) at 0 - 0.15 m depth

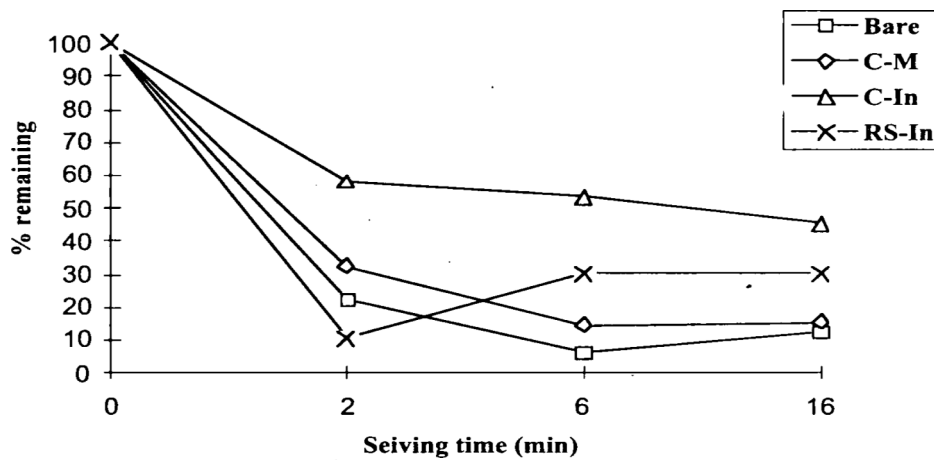


(b) at 0.15 - 0.3 m depth.

Figure 3. Wet aggregate stability of a Noncalcic brown soils 4 months after amelioration.



(a) at 0 - 0.15 m depth



(b) at 0.15 - 0.3 m depth.

Figure 4. Wet aggregate stability of Noncalciic Brown soils at 8 months after amelioration (After two amelioration).

This shows the extent of disintegration of aggregates by wet sieving for up to 16 minutes. The FWC incorporation treatment had the highest percentage of aggregates remaining without disintegration during the experiment. This was followed by the FWC mulching treatment. The rice straw incorporation treatment and bare soil treatment showed a higher percentage of disintegration of aggregates even with only 2 minutes of wet sieving.

At 0.15 - 0.3 m depth, the highest percentage of aggregates remained in the FWC incorporation treatment. As a whole, the percentage disintegration of aggregates is higher in the soils at 0.15 - 0.3 m depth, irrespective of treatments.

Figure 4 represents the wet aggregate stability of different treatments after 8 months. At 0 - 0.15 m depth, the FWC mulching treatment showed the highest percentage of remaining aggregates when sieved. This was followed by the FWC incorporation treatment. At 0.15 - 0.3 m depth, the FWC incorporation treatment showed the highest percentage of remaining aggregates than other treatments during wet sieving.

DISCUSSION

Organic matter content of the soil was increased with amelioration by both FWC and RS. Samples taken at one month and 4 months after incorporation, showed that incorporation of FWC improved the organic matter content better than incorporation with RS. At one month and 4 months after incorporation even the mulching treatment showed an increase in organic matter in the soil. This could be the result of downward migration of organic material into the soil from the applied mulch. All the treatments showed loss of organic matter content with time unless the soil was ameliorated with organic material (RS or FWC). This must be due to the high rate of organic matter decomposition, which prevailed in the soil. In this study, amelioration was repeated only once, but showed the possibility of building up the organic matter content of the soil with time, even though the rate of degradation is considerable.

Incorporating FWC in the soil has significantly increased the MWD index of the Noncalcic brown soil ($p \leq 0.05$). Even after one incorporation, the effect was visible. A high MWD value implies the presence of larger aggregates indicating higher resistance to aggregate breakdown. Clay particles and organic matter both potentially act as cementing agents in stabilising the soil structure formation (Baver *et al.*, 1972) and when, as in these soils, the clay content is low organic matter becomes more important in stabilising the soil structure. Naturally, Noncalcic brown soils are low in organic matter. Incorporation of FWC has increased their organic matter content (figure 1). This must be the main reason for high MWD values in the treatments with FWC incorporation.

According to the MWD values, incorporation of paddy straw treatment does not show marked variation from the bare soil. The contribution of organic matter from the rice straw might not be adequate to change the aggregate status of the soil. Further, rice straw is a raw crop waste (not composted) and it takes more time to decompose and release organic substances to the soil. This may be another reason for poor performance. In this experiment incorporation was restricted mainly to the 0 - 0.15m depth. Changes in MWD values in deeper layers (0.15 - 0.3 m) in incorporation treatments, showed the possible migration of organic matter with irrigation water and rain to deeper layers.

Results of the wet sieving experiment carried out at 4 months after amelioration of Noncalcic brown soils, clearly showed some difference in stability of aggregates among the treatments tested. At 0 - 0.15 m depth, aggregates present in the FWC incorporation treatment soils showed the highest stability. Aggregates in the FWC mulching treatment showed better stability than aggregates in bare soil and rice straw incorporation treatment (figure 3 (a)). Noncalcic brown soil is low in both organic matter and clay. The increase in stability could be due to the organic matter received from FWC. Baver *et al.*, (1972) has reported that, when the soil is low in clay, organic matter becomes more important in stabilising the soil structure. A lower increase in aggregate stability showed by the FWC mulching treatment over bare soil, is probably due to migrated organic material from the mulch to the top layer of the soil. Irrespective of treatments, aggregates found in the depth between 0.15 - 0.3 m showed lower stability than the aggregates present in upper layer of soil (figure 3 (b)). Of all the treatments, only the FWC incorporation treatment showed a higher proportion of stable aggregates at 0.15 - 0.3 m depth. During the irrigation and with rainfall, it is probable that organic matter from the incorporated FWC moved into deeper layers. This may be the reason for high stability of aggregates at 0.15 - 0.3 m depth in the FWC incorporation treatment.

At eight months, both the FWC mulching and incorporation treatments showed higher aggregate stability than for the other treatments at the 0 - 0.15 m depth. Higher aggregate stability is probably due to an increase in organic matter content (figure 1) of the soil by incorporated FWC. Incorporation of rice straw did not show marked variation of the stability of aggregates over bare soil. Organic matter supplied by paddy straw to the soil might be not sufficient enough to increase the stability of aggregates. Further, rice straw contain high silica content which is fairly resistant to decomposition. At 0.15 - 0.3 m of depth, the highest aggregate stability was found in the FWC

incorporation treatment. This shows the improvement of soil aggregate stability extended to deeper layers, though incorporation was confined to a shallow depth (0 - 0.15 m).

CONCLUSION

Amelioration of Noncalciic brown soils using FWC showed the possibility to increase the aggregation of soil particles and their stability. RS did not increase MWD over bare soil, or increase in stability of aggregates. Repeated amelioration is better to sustain the organic matter level of the soil, which eventually helps to increase the aggregation. Increase of wet aggregate stability with amelioration indicates the stability of such aggregates for outside forces like irrigation, rainfall and ploughing.

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