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The Effect of Artificial Macropores on the Amount of Organic Matter in Soils and Plant Biomass.

Yasushi Mori[1], Atsushi Fujihara[2], Kazuto Yamagishi[2].

1. Graduate School of Environmental and Life Science, Okayama University, Okayama, Japan.

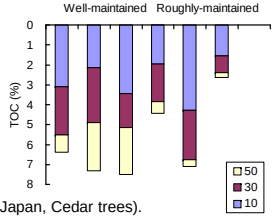
2. Graduate School of Life and Environmental Science, Shimane University, Matsue, Japan.

Contact：yasushim@cc.okayama-u.ac.jp

Backgrounds

Degradation of surface soils

Soil is largest carbon storage body in all terrestrial medium such as vegetation and the atmosphere. However, these days, soils could not show its function as water storage layer or culture medium for plant, because of climate change or rough management. At these condition, soil layer is hard and infiltration is poor, preventing water and air intrusion. Organic matter is accumulated at the surface soil, suffering from erosion and decomposition. Traditional counter measure to enhance infiltration is cultivation, turn over. It makes soil layer softer and agricultural jobs easier. However, it may also break soil aggregates and make soils drier, which would be a cause of erosion and decomposition of organic matter.



Breaking soil aggregates

Dry soils

Compaction by wheels

Fig. 1 Roughly managed forest floor (Japan, Cedar trees).
There are few vegetation (left) and organic matter content is dropped already at 50cm (right).

Ideas for Enhancing Infiltration

Proposed design

A vertical hole was created into the soil and glass fiber was inserted. Capillary force caused by fibrous material introduced vertical transport, while micropore (matrix) enhanced horizontal flow. Because artificial macopore maintains its structure and is effective prior to saturation, it makes it possible effective infiltration than empty macropores.

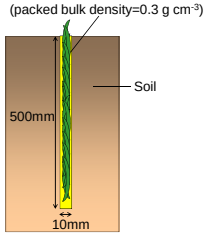


Fig. 2 Schematic of artificial maropore

Hydraulic properties of artificial macropore structure

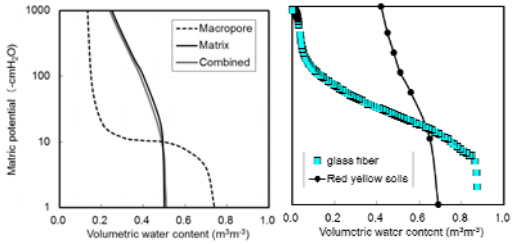


Fig. 3 Water retention curve for natural soils and artificial macroporous soil. Left: Designed function, Right: Actual artificial macropore.

There are significant differences in water retention capacity. Artificial macropore with glass fiber fillings has large pore volume than soil matrix. These differences in water retention characteristics emerged intersection of each characteristic curves. When the soil was saturated, i.e. stormy rainfall event, soil would show surface water. In that condition, capillary forces emerged from glass fiber would drag the surface water into soil profile. When water content decreased and suction emerged at soil matrix, i.e. below intersection point, soil matrix played major part of drainage. Rainfall expected to be effectively delivered to the soil profile, avoiding surface runoff.

Field Experiement

Field design

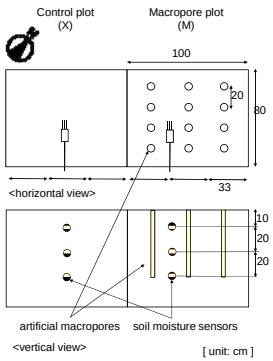


Fig. 4 Schematic representation of field experiment.

Enhancing infiltration in the field experiment

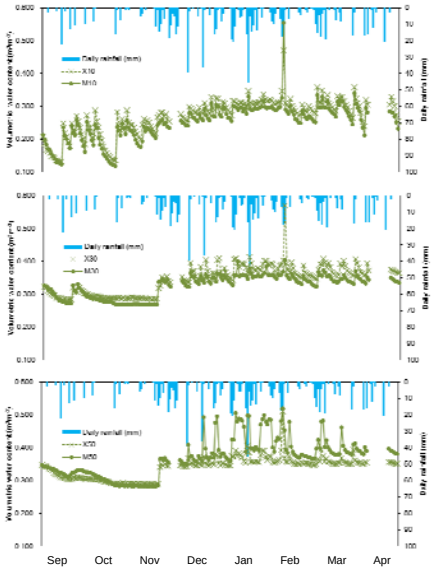


Fig. 5 Daily soil moisture fluctuations (10, 30, 50 cm depth) at control and macropore plot.

Results & Discussions

Organic matter storage in soils and recovery of vegetation

Fig. 6 Field experiment results after enhancing vertical infiltration and organic content recovery.

Table1 Weed flora after one year macropore treatment

Scientific Name	No macropore	S.D.	Macropoore	S.D.
Stellaria	9.17	8.69	0.82	0.25
Poa annua	9.72	0.84	5.74	2.34
Cerastium glomeratum	25.83	4.74	24.82	9.43
Vicia sativa subsp. Nigra	13.31	15.42	107.34	44.79
Equisetum arvense	3.62	0.99	6.05	3.21
Lamium amplexicaule	12.25	15.90	9.44	3.58
Capsella bursa-pastoris	5.87	1.96	0.74	0.56
Calystegia japonica	0.38	0.43	0.17	0.08
Veronica persica	9.64	9.40	12.69	10.55
Erigeron annuus	0.68	0.43	0.15	-
Cardamine scutata	2.54	1.34	N.D	-
Sonchus oleraceus	0.30	0.16	N.D.	-
Lolium multiflorum Lam.	0.76	-	0.27	-
Veronica arvensis	N.D.		0.76	-

S.D.: standard deviation

Unit: (grams of dry matter)/(m^2)

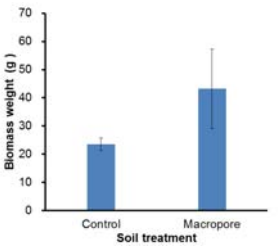


Fig. 7 Net increment of soil total carbon (TC) after one-year macropore treatment.

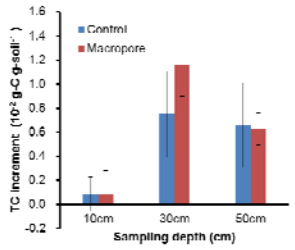


Fig. 8 Plant biomass weight after one-year macropore treatment.

As **Figure 5** showed in the sequence of water content fluctuations, we estimated that artificial macropore with fibrous material successfully induced the surface water into deeper profile.

Figure 6 shows resulted vegetation after artificial macropore field application. Left side shows macropore plot while right side shows control plot. We can easily recognize that green color of the vegetation was deep in macropore plot while it was thin in control plot. Small, short rooted plants were observed in controlled area, while tall, deep rooted plants were observed in artificial macropore area (Table 1).

Figure 7 shows net increment of soil total carbon (TC) at 10, 30 and 50cm depth after the field experiments. Net increment was calculated to find that TC had increased at 30cm depth. We observed successful vertical infiltration at 30 and 50cm depth in Figure 4. Thus, small amount of organic matter at surface soils expected to be induced into the soils which could increase TC at subsurface soil layer. Moreover, plant shooting would affect the total carbon. In this research, TC increment was clearly observed at 30 cm depth.

Figure 8 shows the amount of plant biomass weight, in which macropore plot showed almost two times larger number for control plot. Provided plant seeds may have stayed evenly after preliminary cutting prior to this experiment, enhanced vertical infiltration along with nutrient, organic matter and oxygen supply would stimulate the plant growth environment, which resulted in deep rooted, larger plants.

Conclusions

1. The proposed artificial macropore has the advantage over ill-drained soils. It enhanced the vertical infiltration while fibrous fillings reinforce its structure along with capillary drainage.
2. Rainfall was successfully induced into soil profile at 30 and 50cm depth, which was detected by soil water sensor response.
3. The double amount of plant biomass and the carbon increment in soils were observed at macropore plot when compared with control plot.
4. Average TC increment in compared with control plot was calculated as 0.0019 g-C g-soil^{-1} y^{-1} for macropore plot. The number was converted as 6.26 t-C ha^{-1} y^{-1}. (Note it is first year impact.)

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