

## Environmental Conservation for Devastated Slopes using Ecological Reforestation Technology

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### Abstract

In order to prevent soil erosion and promote reforestation on devastated bare mountainside slopes, a mulching sheet (MS : nonwoven fabric sheet with a three layer structure) and green bag (GB) made of MS containing several seeds, mineral medium, slow releasing fertilizer and mycorrhizal fungi were applied to devastated bare slopes in Japan, Korea, Taiwan and China (Marumoto *et al.*, 1993).

This ecological reforestation technology using MS, GB and mycorrhizal fungi was significantly effective and useful to prevent soil erosion and to recover the early revegetation on bare slopes (Okabe *et al.*, 1997). Several experiment examples in Japan from the past ten years are introduced in this report.

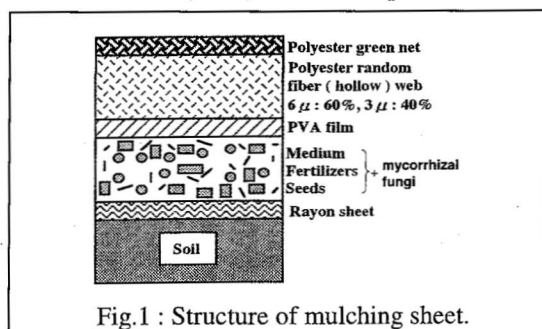
The MS was applied on bare slopes in several places of Shiga, Ehime, Kagoshima and Yamaguchi prefectures, Japan during 1993 ~ 1999. Ectomycorrhizal fungi, *Pisolithus tinctorius* and *Astraeus hygrometricus*, were used as inoculum for young pine trees and endomycorrhizal fungi (AM fungi), *Gigaspora margarita* and *Glomus* sp., were used for grass.

In 1990, Mt. Fugendake, Nagasaki Pref. Japan began volcanic activity after 200 years of inactivity. During 1991 ~ 1994, several large pyroclastic flows completely destroyed the previous vegetation on the mountain slope. Revegetation materials (GB:ca. 2.5kg) were broadcasted by a helicopter in 1995. Seeds of various wild grass and shrub species were used : *Miscanthus sinensis*, *Artemisia princeps*, *Lespedeza cuneata* and the others. *Gigaspora margarita* and *Glomus* sp. were used as the AM fungal inocula. About 3,000 bags per ha were applied to the target area. The grass plants that germinated from the bag were highly colonized with AM fungi.

**Key words:** Ecological reforestation, Mycorrhizal fungi

### 1. Introduction

A mulching sheet (MS: nonwoven fabric sheet with a three layer structure) (Fig. 1) was developed by Marumoto *et al.* (1990) to prevent soil erosion and promote reforestation on bare slopes. The MS consists basically of a polyester random fiber (hollow) web, mineral medium, slow releasing fertilizer, seeds, PVA film and a rayon sheet. From the several experiments, effective functions of MS were 1) drainage of flow water, 2) prevention of soil erosion, 3) decrease of drought damage, 4) decrease of the fluctuation of temperature and moisture in surface soil (Marumoto *et al.* 1997). The MS has been applied on bare slopes in several places in Japan, Korea, Taiwan and China. Marumoto *et al.* (1993) also developed new MS and

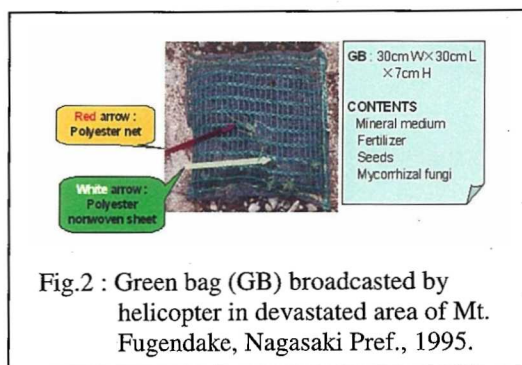


GB (Figs 1 and 2) associated with microorganisms for plants, as ecological reforestation technology on bare slopes.

### 2. Materials and Methods

#### 2.1 Structure of mulching sheet (MS)

A mulching sheet (MS) with three layer structure consists basically of a polyester random fiber (hollow) web, mineral medium, fertilizer, seeds, PVA film and a rayon sheet (Fig. 1). A roll set of MS is 1m W × 50m L. The new MS contained mucorrhizal fungi in the middle layer.



**2.2 Shape of green bag (GB)**

The green bag (GB : 30cm W×30cm L×7cm H, ca. 2.5kg) consists of the mulching sheet (MS), mineral medium, fertilizer, seeds and mycorrhizal fungi (Fig. 2).

**2.3 Seeds and mycorrhizal fungi**

Seeds of various wild grass, shrub and tree included *Miscanthus sinensis*, *Artemisia princeps*, *Lespedeza cuneata* and pine.

Ectomycorrhizal fungi, *Pisolithus tinctorius* and *Astraeus hygrometricus*, were used as inoculum for young pine trees and endomycorrhizal fungi (AM fungi), *Gigaspora margarita* and *Glomus* sp., were used for grass.

**2.4 Application of MS and GB**

Applications of MS on several bare slopes in Japan were conducted at Naganoyama in Yamaguchi Pref., 1990, Tanocho in Miyazaki Pref., 1991, Ehime Univ., in Ehime Pref., 1992 and Sakurajima in Kagoshima Pref., 1994. GB were applied by broadcasting from helicopter at Mt. Fugendake in Nagasaki Pref., 1995 and by fixation with iron pin on MS on a steep rock slope at a site at Nukui Dam in Hiroshima Pref., 2000.

**2.5 Method used for each investigation item**

Investigation methods for recovery of vegetation, amount of soil microbial biomass, colonization percentage by AM fungi and their spore collection were carried out by the fixed point picture and quadrat (2 × 2m square) method, chloroform fumigation method, gridline intersection method and wet sieving method, respectively.

**2.6 Specific identification of inoculated AM fungi (*G. margarita*) at Mt. Fugendake and Nukui Dam site**

Spores of inoculated AM fungi (*G. margarita*) were collected from the root zone of application sites at Mt. Fugendake and Nukui Dam in 2002 - '03. Inoculated *G. margarita* MAFF520054 (CK) was detected by the specific molecular sequence method (Fig. 3). (Yokoyama *et al.*, 2002-a, -b)

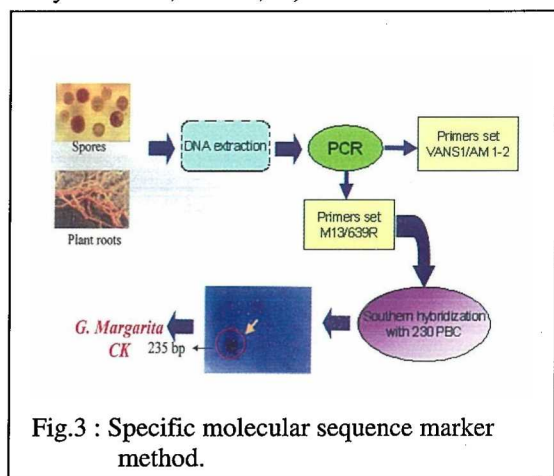


Fig.3 : Specific molecular sequence marker method.

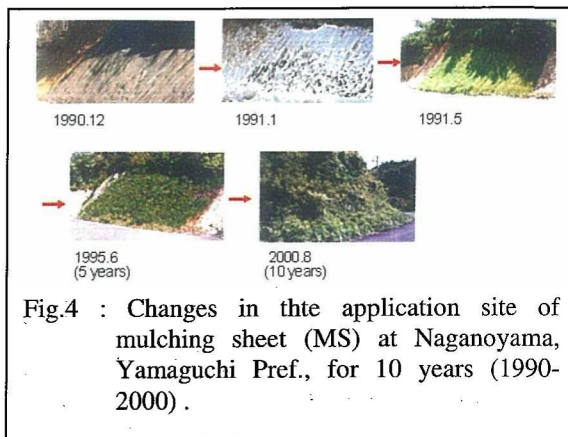


Fig.4 : Changes in the application site of mulching sheet (MS) at Naganoyama, Yamaguchi Pref., for 10 years (1990-2000).

**3. Results and Discussion**

**3.1 Effect of MS and mycorrhizal fungi on soil conservation and reforestation**

Changes in the application site of MS at Naganoyama, Yamaguchi Pref. over 10 years (1990-2000) were shown in Fig. 4. Soil erosion has been completely prevented until now and the initial bare slope was recovered so as to be significantly like the original bush for 10 years after MS application. Neighboring sites were not revegetated because of continuous surface soil erosion.

Growth of pine trees in bare plots and MS with mycorrhizal fungi (Pt) plots at an active volcano at Sakurajima, Kagoshima Pref. for 5 years (1994-1999) was shown in Fig. 5. The growth of pine trees was much better in (MS + Pt) plots than in bare plots

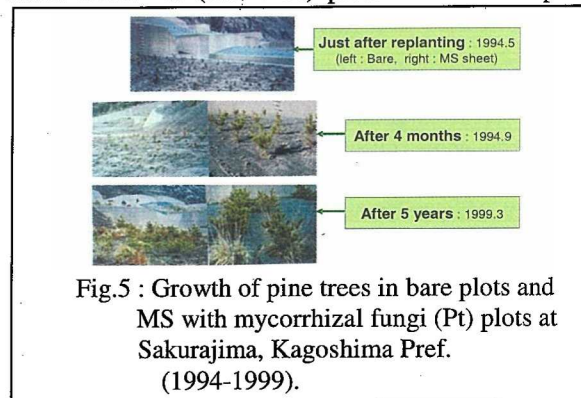


Fig.5 : Growth of pine trees in bare plots and MS with mycorrhizal fungi (Pt) plots at Sakurajima, Kagoshima Pref. (1994-1999).

(Marumoto and Kohno, 2001).

Effect of the application of MS and Pt on the growth of pine trees at Ehime University farm for 5 years (1992-1997) was higher in the following order; (MS + Pt) > MS > Bare plots (Fig. 6).



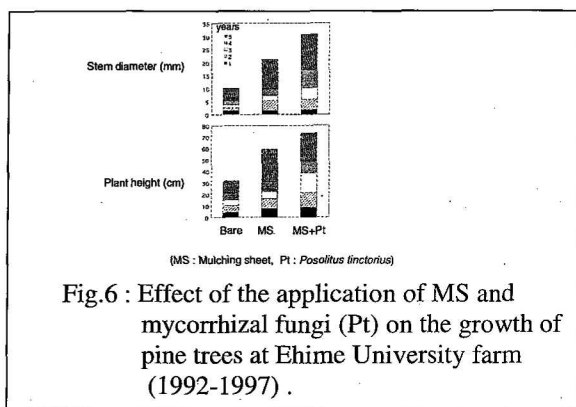


Fig.6 : Effect of the application of MS and mycorrhizal fungi (Pt) on the growth of pine trees at Ehime University farm (1992-1997) .

### 3.2 Recovery of vegetation by GB and mycorrhizal fungi on volcanic devastated slope.

Mt. Fugendake, Nagasaki Pref. began volcanic activities after 200 years of inactivity in 1990. Several large pyroclastic flows completely destroyed the previous vegetation on the mountain slopes. After the volcanic activity ceased, reforestation management started in 1995. GB with AM fungi was broadcast by helicopter on the devastated area of Mt. Fugendake. Recovery of vegetation by GB with AM fungi was significantly higher than that in the bare (control) plots for four years after the revegetation (Fig. 7) (Marumoto and Kohno, 2001).

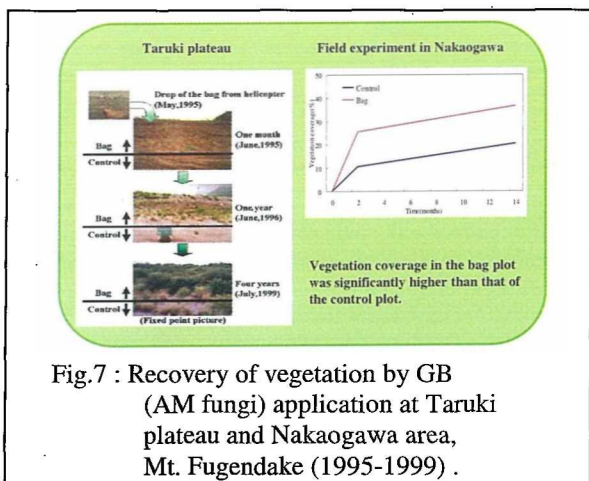


Fig.7 : Recovery of vegetation by GB (AM fungi) application at Taruki plateau and Nakaogawa area, Mt. Fugendake (1995-1999) .

From the analysis of a specifically identified AM fungi (*G. margarita*) at Mt. Fugendake and Nukui Dam, it was shown that this species was still proliferating six years after the revegetation (Fig. 8) (Yokoyama *et al.*, 2002-a, -b).

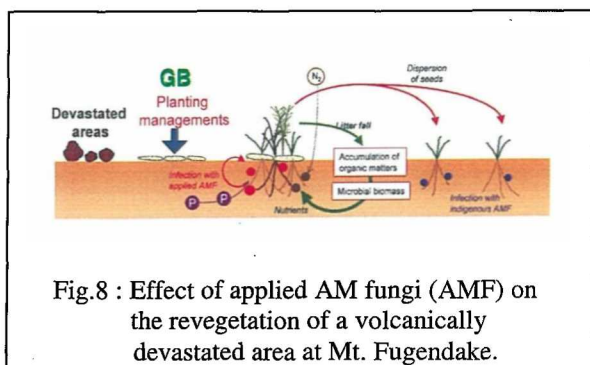


Fig.8 : Effect of applied AM fungi (AMF) on the revegetation of a volcanically devastated area at Mt. Fugendake.

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