Environmental Restoration by New Technology for Prevention of Soil Erosion and Revegetation on Bare Slopes

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Abstract: In order to prevent soil erosion and promote reforestation on devastated bare slopes, the ecological new technology using MS (Mulching Sheet: nonwoven fabric sheet with two to four layer structures) and GB (Green Bag: made of MS containing plant seeds, fertilizers, vegetation base materials, and mycorrhizal fungi) has been applied to bare slopes not only in Japan but also in Korea, Taiwan, China, Indonesia, Vietnam etc. since 1990. From the results of them, the following conclusions were obtained: (1) This technology was significantly effective in preventing soil erosion and promoting the early revegetation on bare slopes; (2) It was suggested that the initial reforestation period could be accelerated for about 50 years by this technology in the Temperate Zone by many field data obtained.

Key words: Ecological reforestation, MS (Mulching Sheet), GB (Green Bag), mycorrhizal fungi.

1. Introduction

In the twentieth century, much environmental destruction was caused by natural disasters and human activities (Fig. 1). As a result of the environmental destruction, some serious problems, for instance, increase of CO₂ concentration and destruction of ozone layer were observed. And vicious circle of environmental destruction is circulating now (Fig. 2). Then, serious pollutions of air, water and soil occurred in the twentieth century.

Water resource is the most important matter for human beings. Fresh water is about 2.53% of total amount of water (138.6 × 10⁸ million ton) on the earth. And, available fresh water for human is about 0.34% of fresh water (quite small amount of available fresh water). Further, about 40% of river water is polluted now.

In order to maintain water resource and reduce CO₂ concentration in atmosphere, revegetation and reforestation under preventing soil erosion are the most important matters. A MS (Mulching Sheet: non-woven fabric sheet with four layers' structure at most, Fig. 3) and a GB (green bag: 3-5 kg made of MS containing plant seeds, fertilizers, vegetation base materials and mycorrhizal fungi, Fig. 4) were developed by Marumoto, T. et al. [1, 2] and were applied to devastated bare slopes in many countries (1995-2016). It was found that this ecological reforestation technology using MS, GB and mycorrhizal fungi [3] was significantly effective and useful to prevent soil erosion and to promote the early revegetation on bare slopes.

In this paper, some construction cases of environmental restoration by the use of new technology with which the multi-function of MS (Fig. 5) and GB including mycorrhizal fungi (Figs. 4 and 6) were utilized for the prevention of soil erosion and reforestation on bare slopes are introduced (Figs. 7-12).

2. Materials

2.1 MS

The basic structure of MS (commercial name “Takino-Filter”) is shown in Fig. 3. MS is composed
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Fig. 1 Causes of environmental destruction.

Fig. 2 Vicious circle of the environmental destruction.

of four layers at most: the first layer is polyethylene protection net; the second layer is polyester non-woven fabric (Web); the third layer is composed of plant seeds, fertilizers and vegetation base materials and the fourth layer is cotton base cloth. When the main purpose is prevention of soil erosion, MS of two layers composed of the first and the second layers is used mainly. From the experimental results during 5 years (1987-1992), it was found that MS had many interesting functions as Fig. 5 [4]:

1. Prevention of surface soil erosion under 100 mm rainfall per hour (fix the surface soil);
2. Maintenance of the moisture under the sheet (decrease of drought damage);
3. Maintenance of the temperature under the sheet in winter (decrease of frozen damage);
4. Well drainage in the sheet;
5. Softening of the rain drop impact;
6. Improvement of root zone in the soil (increase of microorganisms);
7. Acceleration of soil formation.

2.2 BG

The basic structure of BG is shown in Fig. 4. GB was initially developed to promote reforestation by broadcasting from helicopter in large area of devastated site covered with the pyroclastic flow deposit in Mt. Fugendake, Shimabara-shi, Nagasaki, Japan in 1995. GB is composed of three components: the first component is protection net made of polyethylene, biodegradable polyethylene or palm etc.; the second component is non-woven fabric sheet made of polyester etc. and the third component is composed of plant seeds, fertilizers, vegetation base materials and mycorrhizal fungi. After then, GB has been used in many devastated lands such as pyroclastic flow deposit except Mt. Fugendake, mine site and highly acidic soil site etc.
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Fig. 3  Basic structure of MS.

Fig. 4  GB broadcasted by helicopter in devastated area of Mt. Fugendake, Shimabara-shi, Nagasaki, Japan, 1995.
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2.3 Mycorrhizal Fungi

Mycorrhizal fungi are one of the most popular symbiotic microorganisms in the world. Effect of ectomycorrhizal fungi (Suillus sp.) on the growth of young pine seedling and their colonization for 6 months (2001) are shown in Fig. 6. Plant growth and revegetation of young pine seedling were accelerated for 6 months by mycorrhizal fungal inoculation. The MS and GB containing mycorrhizal fungi were usually used for the recovery of bare slopes in Japan.

3. Results and Discussions

3.1 Reforestation of Bare Slope at Naganoyama Mountain Site of Kanokami, Shunan-shi, Yamaguchi, Japan (1990-2000, Fig. 7)

MS was applied on bare slope of mountain site (1,000 m height, frozen area in winter time) of Kanokami, Shunan-shi, Yamaguchi on Dec., 1990. Revegetation progressed yearly and recovered to almost the same as former situation of mountain site after 10 years. And the number of soil microbes such as
bacteria and fungi under MS was higher than the bare site.

3.2 Revegetation of Bare Slope of Shirasu (White Volcanic Ash Soil) at Tokiya District, Miyazaki-shi, Miyazaki, Japan (1991, Fig. 8)

Shirasu (white volcanic ash soil) is located in south area of Kyushu Island (Miyazaki and Kagoshima). The prevention of soil erosion of “Shirasu” is usually very difficult under strong rainfall in rainy season in southern Japan. As shown in Fig. 8, soil erosion was completely prevented and revegetation also succeeded 2 months later after construction of MS on bare slopes at Tokiya district, Miyazaki, Japan in June-Aug., 1991. And, the amount of soil microbial biomass C increased in MS plots than in bare (control) plots after 1 and 3 years.

3.3 Reforestation of Volcanic Barren Area of Mt. Fugendake, Nagasaki, Japan (1995-1996, Figs. 9 and 10)

Situation of Mt. Fugendake area after volcanic explosion at Shimabara peninsula is shown in Fig. 9. South side of mountain was burned completely by pyroclastic flow (about 1,300 degrees Celsius). Construction of reforestation was started on burned area in 1995. GB was broadcasted on the barren area by helicopter (Fig. 10). Four years later after broadcasting of GB on bare field, the land had been completely covered with bush and young trees. A large number of trees grew higher than 5 m tall 10 years later [5]. And the inoculated arbuscular mycorrhizal fungus, Gigaspora margarita MAFF520054 strain, was detected by the specific molecular sequence method four years later after construction and it was suggested that the fungus had contributed to the establishment and the growth of introduced plant species and the promotion of reforestation [6-8].

3.4 Reforestation of Rock Slope on Dam Sites, at Nukui Dam, Kake, Akiohta-cho, Hiroshima by MS and GB (1999-2015, Figs. 11 and 12)

Nukui Dam with arch style was constructed at Kake, Akiohta-cho, Hiroshima and the construction for reforestation of rock slope on dam sites was executed.
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in 1999. The situation of reforestation on both dam sites after 9 and 15 years were shown in Figs. 11 and 12. Rock slope on dam sites had completely recovered by MS and GB using these ecological technologies. And the survival of inoculated AM (Arbuscular Mycorrhizal) fungus was also confirmed in this site and it was suggested that the fungus contributed to the success of reforestation [8].

4. Conclusion

In order to prevent soil erosion and promote reforestation on devastated bare slopes, the ecological new technology using MS (nonwoven fabric sheet with four layer structure) and GB (made of MS containing plant seeds, fertilizers, vegetation base materials, and mycorrhizal fungi) has been applied to bare slopes not only in Japan, but also in Korea, Taiwan, China, Indonesia, Vietnam etc. since 1990.

(1) This technology was significantly effective in preventing soil erosion and promoting the early revegetation on bare slopes.

Fig. 8 Revegetation of bare slope of Shirasu (white volcanic ash soil) at Tokiya district, Miyazaki-shi, Miyazaki, Japan, 1991.

Fig. 9 Situation after explosion of Mt. Fugendake, Nagasaki, 1994.
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Fig. 10  Reforestation of volcanic barren area at Mt. Fugendake by broadcasting of Green-bags using helicopter (1995-1999) [9, 10].

(a) Before construction of rock slope.          (b) 9 years later after construction, 1999.

Fig. 11  Reforestation of rock slope on dam sites, Nukui Dam, Kake, Akiohta-cho, Hiroshima by MS and GB, 1999-2008.

Fig. 12  Nukui Dam sites after 15 years of reforestation, 2015.
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(2) It was suggested that the initial reforestation period could be accelerated for about 50 years by this technology in the Temperate Zone by many field data obtained (Fig. 13).

Finally, authors strongly hope that this technology is expanded and utilized on bare slopes and the authors would like to contribute to the environmental restoration in the world.

References


