G-1.3 Integration of Prevention and Rehabilitation Technology for Desertification

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Abstracts The research project aims at proposing systematic utilization of elementary techniques for rehabilitation and establishment of sustainable biological production in a desertificating area. Outcomes obtained were summarized as following: (1) Continuous monitoring of natural succession process from disturbed and cleared ground condition indicated that several species belonging to *Atriplex* spp., *Enneapogon* spp., and *Halosarcia* spp. were identified as pioneer plants superior to salt tolerant and drought tolerant. (2) Salt was taken up by salt tolerant plants amounted so much as 40 gram sodium per a plant to significantly reduce salt content in the rhizosphere. A coupled planting between salt-tolerant and non salt-tolerant plants named as "companion planting method" was proposed as the next step. Significantly more *Acacia* spp., which was legume, survived associated with *Atriplex* spp. for six months showed companion planting method was effective for less salt tolerant plant introduction. (3) In order to improve low fertility and high evapotranspiration, soil additives such as livestock excrement were tested to develop more useful plants. The additives were valuable to the growth of vegetables and some shrub trees. Shapes of organic materials made mainly from livestock excrement were also tested. Agricultural production could be harvested if the organic materials were set to pot shapes to concentrate into the rhizosphere. (4) In order to satisfy local benefit, basic study about sandalwood silviculture was carried out. Smoked water that solved ash and smoke of burned plant residue to water, worked for increasing the germination from less than 20% that was average in extensive silviculture to more than 80%. The technologies studied in the project were integrated to two technologies: core technologies available wherever desertification occurs, and adapting technologies available to a specific local area. Efficiently combining the two technologies, the core technologies can be applied to desertificating area as a rehabilitation plan.

Key Words Desertification Protection, Elementary Techniques, Salt Tolerant Plants, Systematization of the Techniques, Western Australia

1. Introduction

Convention to Combat Desertification (CCD) was adopted in 1994, and Japan concluded CCD in December 1998. Not only governments and researchers in desertification progressing countries, but also those people in Japan are required to make more international collaboration to combat desertification. In Japan various technologies has been proposed since 1980's, that seems effective to prevent desertification; the technologies consisting of water resource production and reservation, soil fertile management, and cultivating techniques were arranged as a library called "elementary technologies"[1]. Most of the technologies were tested under modified arid or semi-arid condition within Japan as simulated experiments. Very few of the technologies were tested in desertificating area.

2. Research Objective

The project aimed at proposing systematic utilization of the elementary techniques for rehabilitation and establishment of sustainable biological production in a desertificating area in Western Australia[2]. How can we overcome the problem and establish the sustainable productivity? Four steps were needed; (1) introducing salt tolerant plants, (2) improving saline environment, (3) improving soil fertility for useful plants production, (4) local cash crop production.

3. Research Methods, Results and Discussion

3.1 Introduction of salt tolerant plants

Just after huge impact such as cleared or disturbance of soil, rapid growing and highly salt tolerant plants occurred according to natural succession process[3]. The process provides us an important information for selecting plants. Transacts whose size was 1.5 by 20 meters were settled on the embankment of a tailings storage facility. Sequent monitoring was performed every second months to identify the species and determine germination timings. The most dominant species is *Atriplex codonocarpa*. The others are *Atriplex lindleyi*, *Enneapogon polyphyllus*, *Halosarcia doleiformis*, and *Halosarcia doleiformis*. The plants contributed rapid cover of the bare soil surface within six months after the soil dressing. The dominant plants at first were annual, short-lived grasses and shrubs, which were increasing toward to August and decrease after then. Perennial shrubs that covered less than annual, short-lived shrubs remained throughout the year. The germination monitoring shows most plants were germinated in late autumn or winter. The best seeding season were April to August, it varied a little according to plant species.

3.2 Improving saline environment

It is reported that the salt tolerant plants occurred at the early stage as pioneer plants could absorb a plenty of salt into themselves[4]. Therefore as the next step, we determined how much salt the plants took up. Natural stands of five species of salt tolerant plants (3 species of *Atriplex*, *Halosarcia* sp., and *Maireana brevifolia*) were harvested to determine sodium content, fresh weight, and dry weight. Rough amount of sodium in the plants was calculated with multiplying the sodium content by the dry weight. *Atiplex lindleyi* was able to absorb as much as 44g of sodium per a plant as the maximum, and the other species absorbed salt from 5 gram to 13 gram per a plant. As well as salt content in the plants, soil salinity changes around root zone were also determined. The soil salinity around the salt tolerant plants was significantly lower than the soil at 35cm apart from the plant. From the two results, salt remained in the soil moving into the plant, that leads to the improvement of the soil salinity by salt tolerant plants.

3.3 Introduction of less salt tolerant plants

If the area are expected more productive one, introducing less salt tolerant plants are needed as the next step. There is a mixed planting with high salt tolerant plants and less salt tolerant plants, while the salt tolerant plants are left as they are. We named the coupled planting as "companion planting method". After salt tolerant plant such as *At. lindleyi* grew well, less salt tolerant plants of *Acacia craspedocarpa* and *Ac. jenera* that are useful for fodder or soil fertility conservation were planted approximately 10cm apart from the stem of *At. lindleyi*. The survival rate of both *Acacia* spp. without *At. lindleyi* dropped down quickly just after the transplanting, on the other hand, *Acacia* spp. with *A. lindleyi* kept better survival rate for more than six months. Competition of water among salt tolerant plants and less salt tolerant plants can happen; therefore the companion planting method is especially useful where saline condition was most severe limiting factor for plants survival. The trial was also carried out under irrigated condition, but the amount of water is quite small, 60ml per a plant per 3 days. *Acacia* spp. with *A. lindleyi* were able to survive for longer without irrigation than those without *A. lindleyi*. Reducing the amount of irrigated water leads to the water saving in arid region. Moreover, using companion planting method saves time to recover the vegetation because the companion planting method makes it possible that desalination process parallel the next planting process.

3.4 Improvement of soil fertility for useful plant production

Companion planting method was useful when less salt tolerant shrubs were established, however it was found that nutrient competition might happen if the method was applied to vegetables with salt tolerant plants. Adding fertilities is needed in order to establish agricultural land use. Therefore, compost made of livestock excrement as available organic source was tested. Mixture of horse excrement and wheat flour equivalent to $42kgN \cdot 10a^{-1}$ was formed to pot shape and slurry shape. Pakchoi, Chinese leaf vegetable was grown with the two types of compost. Although pakchoi with slurry shape grew best at the early stage, pot shape showed the best plant growth and this was the only form with which pakchoi was harvested. Plant roots with pot shape was able to take up nutrition continuously after plant roots reached the pot edge. Besides the more effective nutrition supply, the pot shape was effective for water holding in the root zone. The result shows that products can be harvested in low fertile area if such organic materials are set around the root zone intensively.

3.5 Local cash crop production

The last step is local cash crop production. Crops should be selected according to local demands. In Western Australia it is sandalwood. Sandalwood is one of principal products to export since the 19th century because it has good quality of aroma useful for medicine or perfume. Preliminary germination test was done with some pre-treatment. Scarifying seed skin, and smoke water that solved ash and smoke of burned plant residue to water was applied as pre-treatment. Both treatments worked higher germination, 94% and 70% respectively 6 weeks after sowing seeds, than average conducted by Conservation And Land Management, that was approximately 20%[5]. There were a lot of reports that smoke water was effective to plant germination[6]. The study indicated that smoke water was also effective to germination of sandalwood.

3.6 Integration of the technologies

The technologies described above were integrated as a flow of desertification recovery. It is desirable to introduce vegetation step by step from salt-tolerant plants to less salt tolerant plants using companion planting method. Conserving fertility and local industry promotion are also important for further plant production as described in the latter three technologies. From the different viewpoint, the outcomes were classified into two technologies, that is "core technologies" available wherever desertification occurs, and "adapting technologies" available to a specific local area. When the core technologies are applied to other desertificating area, a different type of "plug" has to be developed. In other words, if we joint the two technologies well, revegetation or plant production will be successful from potential productive area. Social and economical viewpoints will be indispensable for the adaptation. The further study should be performed concerning the development of appropriate plugs fitted to each desertificating areas.

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