G-1.3 Evaluation for Prevention and Rehabilitation Technology of Desertification

Contact person Taniyama Ichiro
Soil Conservation Laboratory
Department of Natural Resources
National Institute of Agro-Environmental Sciences
Ministry of Agriculture, Forestry, and Fisheries
3-1-1 Kannondai, Tsukuba, Ibaraki 305, Japan
Tel:+81-298-38-8270 Fax:+81-298-38-8270
E-mail:erosion@niaes.affrc.go.jp

Total Budget for FY1995-FY1997 103,314,000Yen (FY1997; 39,101,000Yen)

Abstract The final goal of this project is to find and evaluate the elementary prevention and rehabilitation techniques for desertification in Western Australia. Some useful techniques and plant species were accepted for rehabilitating desertificated soil, such as distilled techniques using solar radiation energy, soil conditioner like super-water-absorbent polymer made from N-acetylamide, vesicular-arbuscular mycorrhizal fungi, humic fertilizer and desert stress tolerant plants originated in Australia.

Key Words Evaluation of elementary techniques, Humic fertilizer, Super-water-absorbent polymer, Vesicular-arbuscular mycorrhizal fungi, Western Australia

1. Background and purpose

The project's purpose is to search for and evaluate the following elementary techniques:

a. Distillation techniques using solar energy.

b. Search for and use of desert-stress-tolerant plants.

c. Desertified soil improvement using soil conditioners such as super-water-absorbent polymer (SAP).

2. Method and field layout

2.1 Experimental site

The experimental field used for demonstrating desertification prevention and rehabilitation technology was in Kalgoorlie, Western Australia. Distillation equipment was solar-powered and photovoltaic power generator, drip irrigation, and underground drainage.

2.2 Distillation using solar energy

The distiller is a 3-meter-wide, 2-meter-deep, windtight container with two slightly reclined transparent plastic roofs. After gray water in sinks in the distiller is heated and evaporated by solar radiation through the plastic roofs, vapor condenses on the roof surface and is collected at gutters beside the distiller.

Collected water has been measured since January 1997 except in winter. Each morning, 20 mm of gray water was fed into sinks. Water accumulated by the next morning was counted as the water produced for one day.

2.3 Search for and use of desert-stress-tolerant plants

Soil and plant surveys by the Department of Agriculture and Department of Conservation and Land Management have been progressing almost everywhere in Western Australia[1,2]. Based on results, we surveyed plants near the research site working with local researchers to select plants that were desert-tolerant and useful for grazing, aromatic applications, medical use, etc. Germination testing, nursery raising, and transplanting were conducted to measure germination and rooting rates.

2.4 Desertified soil improvement using soil conditioner such as SAP

Vesicular-arbuscular mycorrhizal fungi (VAM), rhizobium, N-acetylamide SAP, Humic fertilizer, and mulching material (wood chips) were used as soil conditioners.

These materials were applied alone or in combination to evaluate the effects of treatment, mainly by measuring plant growth (Table 1). The following materials were applied:

- VAM: applied to the soil surface in planting pots at seeding.
- Rhizobium: applied to the soil surface in planting pots at seeding.
- SAP: painted on the potting mix surface.
- Humic fertilizer: mixed in the field when cultivating before transplanting.
- Mulching material: applied around seedlings (about 30 cm) after transplanting.

Some species were not inoculated with VAM or rhizobium, so not all treatments were applied to all species (see Treatment column, Table 1).

2.5 Field layout

The research field was constructed in August 1997. A weather tower was installed in June 1997 to measure air temperature and humidity, wind direction and speed, net solar radiation, and rainfall.

A total of 85 to 392 shrub and vegetables were planted between taller trees. The effect of improvement materials on plants was then evaluated.

Irrigation water was 4,000 ppm, combining treated municipal water and saltwater stored in an unused open pit containing 12,000 to 13,000 ppm total dissoluble salts. Irrigation by tube dripping was scheduled to make yearly mean irrigation 5 mm.

Nursing began in January 1997, and transplanting in May 1997. Growth was surveyed for rooting rate and plant height in July and October 1997 and February 1998; plant width was surveyed in October 1997 and February 1998.

3.Results

3.1 Solar-powered desalination equipment

The relationships was observed between net-solar radiation and the amount of water collected with/without insulation boards (Fig. 1).

3.2 Plants selection

Seed production, germination percentage, and rooting rate were observed (Table 1). Blanket-listed plants used common local names.

3.3 Growth survey

Seven species of tree, shrub, and vegetable with high rooting rates among transplanted plants were measured (Table 2). Two species --*Atriplex vesicaria* and baby corn-- was notably affected with the improvement materials.

4. Discussion

4.1 Distillation using solar energy

Water collected before insulation board installation (January to March 1997) was much lower than we had expected (Fig. 1). This was assumed due to much heat lost to leakage without concomitant water heating due to poor insulation[3]. Thick insulation boards were therefor installed beneath sinks in September 1994. Water yield then increased three-fold. In summer, 24 to 26 MJ/m^2/day of solar radiation are expected, yielding 2.5 to 3.0 L/m^2/day of pure water.

4.2 Plant selection

Plants selected were mainly shrubs, which are useful particularly for grazing and show the effects of elementary techniques clearly due to their fast growth of candidate plants (Table 1), only half of species seeds were available.

Germination testing was done only for tree and shrub species. Flower and vegetable seeds were garden varietty and exceeded 90 % in actual seeding in the nursery. Tree species germinated well, but some shrubs had germination of less than 10%. Germination testing is required because germination varies with the collection time and weather. *Frankenia* spp. and *Maireana georgeii* showed interesting results: *Frankenia* spp. did not germinate at all in either nursery or germination testing, but germinated and grew well in transplanting. *M. georgeii* grew poorly in the nursery despite good germination testing. These results may have benn due to germination test pretreatment. Hard seed hulls of the *Maireana* genus, for example, were removed in germination testing, but not in actual nursery seeding. In some cases, germination testing may therefore not reflect actual field seeding, which is a problem to be explored in the future.

Four tree, 6 shrub, and 8 vegetable and flower species, grew sufficiently for transplanting. Rooting rates differed widely by species.

Three species of *Senna artemisiodes* shrub did not root well. Legumes in general are not strongly salt-tolerant, and *Senna artemisiodes* proved to be especially so, compared to three other species, we selected, dying before soil conditioners could work. These results show that it is important to manage rrigation carefully, especially just after transplanting.

Flower and vegetable rooting rates were quite low, although they grew better with VAM while in the nursery, perhaps due to insufficient transplanting time. The transplanting schedule was delayed, moved from early summer to midsummer because of a lack of staffing.

4.3 Evaluation of soil conditioner

Growth was surveyed against good rooting plants to evaluate the effects of soil conditioner (Table 2).

Shrubs were measured by provisional volume rather than height, because they were eaten by worms early on and grew sideways rather than upward. Average shrub height was taller for those treated with SAP than without, although this was not statistically significant. Fertilizer was ineffective for *Frankenia* spp., but other species grew significantly better with it. Mulching accelerated the growth of *A. vesicaria*, but not that of *Frankenia* spp. or *M. brevifolia*. Mulching material such as wood chips is reported to attract termites in tropical areas[4); in our case two species damaged more by worms, perhaps similar to termite problem in that worms appeared attracted to mulch in the field.

Soil conditioner application to trees made little, if any, difference in our survey timeframe, because of their slow growth.

Among vegetables and flowers, gazania and onion were relatively well rooted but were eaten by rabbits before they could be measured. Baby corn and tomatoes were transplanted after fence construction (Table 2), and thus could be measured. All treatment produced good plant growth except for VAM application to tomatoes.

Soil conditioner accelerated the growth of baby corn and tomatoes, although their rooting rate was only 30 %. Soil conditioner application accelerated plant growth after rooting, but not rooting itself. For good rooting, it is important to select salt-tolerant plants and to plan transplanting to minimize shock to plants.

5. Conclusion

Solar-powered water desalination equipment at the research site produced 2.5-3 L/m^2/day in summer.

Several plant species suited to desert rehabilitation were selected through germination testing, seeding, and nursery raising, and transplanting to the field.

Plant growth was accelerated by applying elementary techniques early after rooting. Applying a soil conditioner as such did not increase the rooting rate. Increased irrigation and appropriate transplanting time proved to be very important.

References:

1) Cunningham G.M., Mulham W.E., Milthorpe P.L. and Leigh J.H. (1981) Plants of Western New South Wales. Soil Conservation Service of NSW. NSW Government Printing Office.

2) Pringle H.J.R., Van Vreeswyk A.M.E., and Gilligan S.A. (1994) An inventory and condition survey

of rangelands in the North-Eastern Goldfields, Western Australia. Western Australian Department of Agriculture, Technical Bulletin Number 87.

3) Ishikawa, Y. and Matsumoto, S. (1996) Abstract of 1996 meeting, Japanese Association Arid Land Studies, 7, 7-8 (in Japanese)

4) Asakawa, S. (1995) Afforesting techniques in tropical areas (Nettai no zourin gijutsu), Japan International Forestry Promotion and Cooperation Center, 89

Table 1 Selected plant species, their germination and rooting rates.

Species	seed availability	germination rate (%)	Transplanting date	rooting rate	number of seedlings	treatment
<Trees>						
Acacia craspedocarpa	*yes*	92.0	Sep.-97	39.6	85	V,F,S,R
Acacia acuminata	*yes*	89.0	Dec.-97	87.1	240	V,F,S,R
Eucalyptus torquata	*yes*	120[a]	Sep.-97	6.3	85	V,F,S,M
Eucalyptus salubris	*yes*	354[a]	Dec.-97	82.3	240	V,F,S,M
					650	
<Flowers and Vegetables>						
Petuniaa spp ('Fluffy Ruffles')	*yes*	<10.0	-	-	0	V, F, M
Allium fistulosum (Onion)	*yes*	>90.0	Sep.-97	39.0	384	V, F, M
(Baby Corn)	*yes*	>90.0	Feb.-98	30.2	392	V, F, M
Palcus carota (Carrot)	*yes*	>90.0	Sep.-97	5.7	384	V, F, M
Gazania spp (Gazania)	*yes*	>90.0	Sep.-97	71.6	384	V, F, M
Chrysanthemum morifolium (Chrysanthemum)	*yes*	>90.0	Feb.-98	<5.0	392	V, F, M
Sorghum hybrid (Sorghum)	*yes*	>90.0	Feb.-98	<5.0	392	V, F, M
Lycopersicon esculentum (Tomato)	*yes*	>90.0	Feb.-98	31.3	392	V, F, M
Cucumis melo (Melon)	*yes*	>90.0	Feb.-98	<5.0	392	V, F, M
					3,112	
<Shrubs>						
Atriplex bunburyana	*yes*	4.5	-	-	0	
Atriplex vesicaria	*yes*	66.8	Jun.-97	96.0	384	S, F, M
Cralystylis subspinescens	*yes*	4.4	-	-	0	
Dodonea lobulata	*yes*	14.5	-	-	0	
Frankenia spp	*yes*	0.0[b]	Jun.-97	86.7	384	S, F, M
Maireana brevifolia	*yes*	30.5	Jun.-97	69.4	384	S, F, M
Maireana georgeii	*yes*	79.0[c]	-	-	0	
Senna artemesiodes ssp. artemesioiedes	*yes*	46.5	Jun.-97	7.6	384	V, F, M
Senna artemesiodes ssp. nemophila	*yes*	46.0	Jun.-97	9.9	384	V, F, M
Senna artemesiodes ssp. struii	*yes*	56.5	Jun.-97	10.2	384	V, F, M
Cassia oligophylla	*no*	-	-	-	-	
Eremophila glabra	*no*	-	-	-	-	
Eremophila granitica	*no*	-	-	-	-	
Eremophila maculata	*no*	-	-	-	-	
Eremophila minista	*no*	-	-	-	-	
Eremophila oldfieldii	*no*	-	-	-	-	
Eremophila scoparia	*no*	-	-	-	-	
Olearia muelleri	*no*	-	-	-	-	
Scaevola spinescens	*no*	-	-	-	-	
Stipa scabra	*no*	-	-	-	-	
					2,304	
				Total	6,066	

a: The numbers mean germination number (plants/g) instead of percentage, because it was difficult to count small seeds.

b: The species grew well after the germination test.

c: The species did not grow as well under the nursery condition as the germination test.

Table 2 Effect of soil conditioner and fertilizer on plant growth.

Species	Treatment	applied	not applied
A.vesicaria	SAP	43,903	39,632
canopy(dia.) x height	Fertilizer	49,429 **	34,288
(cm^3)	Mulch	43,753	39,913
Frankenia spp.	SAP	2,570	2,210
canopy(dia.) x height	Fertilizer	2,304	2,474
(cm^3)	Mulch	2,029 *	2,717
M. brevifolia	SAP	34,840	33,914
canopy(dia.) x height	Fertilizer	37,489 *	30,157
(cm^3)	Mulch	24,631 **	42,069
E.salubris	SAP	34.63	35.13
height(cm)	Fertilizer	35.86	33.89
	Mulch	34.42	35.28
	VAM	35.00	34.73
A.acuminata	SAP	37.94	35.03
height(cm)	Fertilizer	37.83	34.95
	VAM	37.80	35.13
	Rhizobium	35.60	37.32
Baby Corn	Fertilizer	39.71 **	28.53
height(cm)	Mulch	35.79	33.08
	VAM	35.38	33.53
Tomato	Fertilizer	28.87	24.93
height(cm)	Mulch	29.14	25.93
	VAM	25.85	27.86

*,** significant at the 0.05 and 0.01 probability levels respectively

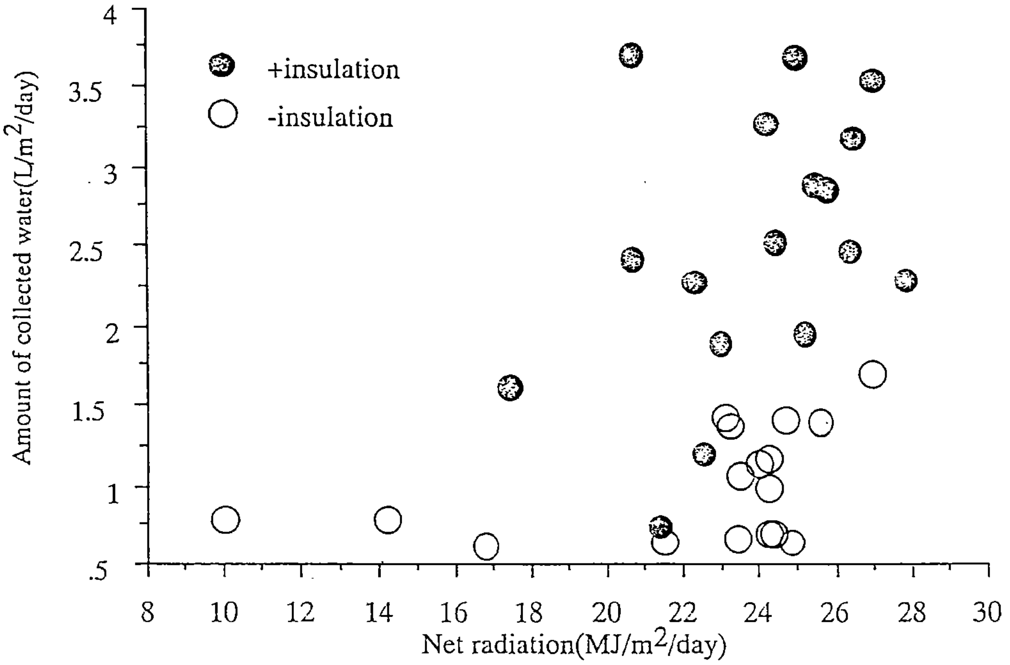

Fig.1: Relationships between net radiation and amount of collected water with/without insulation