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INDOLE CHEMISTRY FOR COMBATING YELLOW SAND AND DESERTIFICATION DIRECTED TOWARDS STOPPING GLOBAL WARMING [#]

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Abstract – Various derivatives of indole-3-carbaldehyde are found to be root regulators and they are named SOMRE compounds. Since some of them are potent root promoters and make roots three times longer than usual, their possibilities for increasing food production, combating yellow sand and desertification in Gobi desert, China, were examined. All preliminary experiments are thus far working well. For greening desert and stopping the global warming, it is vital importance to sow seeds to vast area of sand dune all at once. We are now on the stage to scatter seeds, pretreated with SOMRE, to sand dune by airplane.

1. INTRODUCTION

A serious problem in recent years is global warming[1] threatening the survival of lives on the earth. Green house effect gases such as carbon dioxide, chlorofluorocarbon, methane, carbon monoxide etc. are believed to be responsible. Among them a main cause at present is carbon dioxide that has been emitted by human activity including fossil fuel burning, over-cutting of trees, and overgrazing. They have led to deforestation and desertification. For example Gobi desert in Inner Mongolia in China is now spreading and drifting rapidly menacing to engulf rivers, houses, and cities.

We had concluded the best way to cure the global warming is the changing deserts to green tracts with full of plant. Plants and grasses can not only cover the surface of deserts but also absorb a greater mass of

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carbon dioxide resulting in prevention of the outbreak of yellow sand. They would in the long run recover meadows and forests as they were in olden times, and culminating in the ending of desertification.

This brief review summarizes how we have been fighting desertification aiming at stopping global warming, making use of indole chemistry.

2. A mechanism of desertification and an idea for its rehabilitation

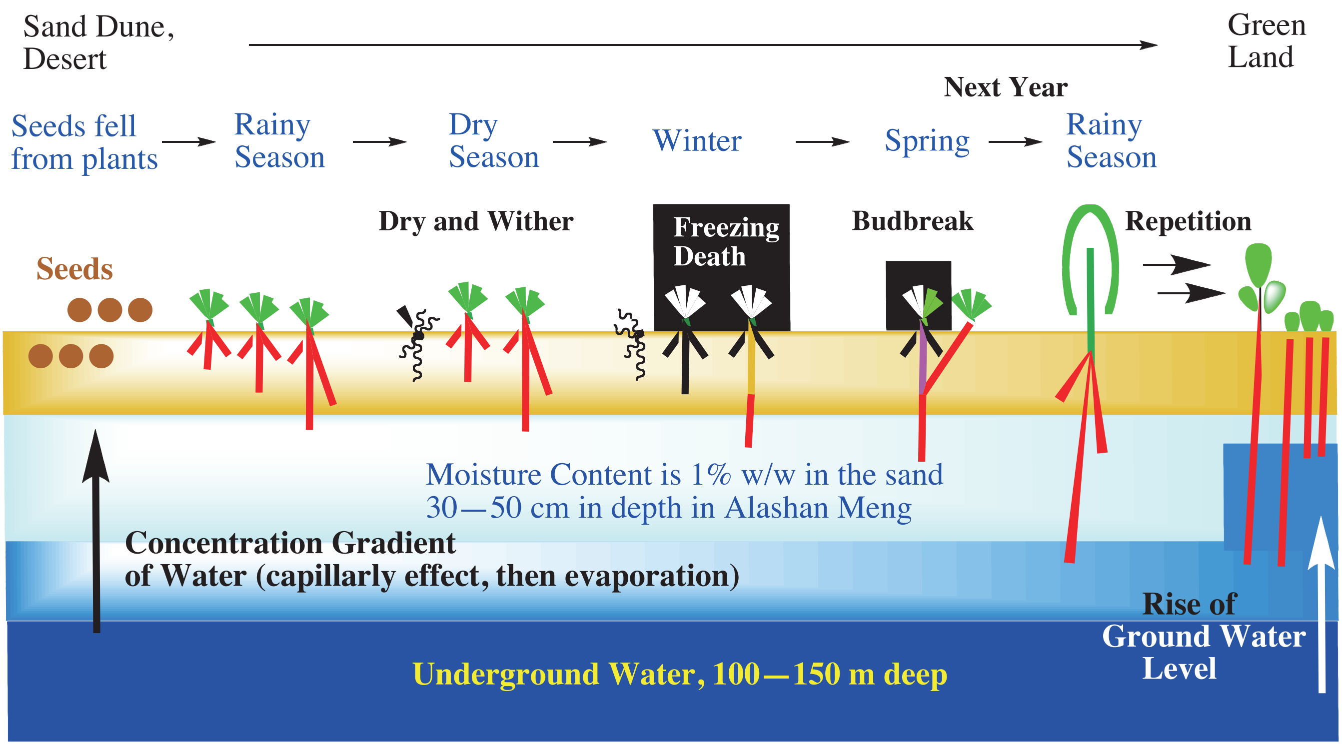
How on earth can we make desert full of plant? To get a hint of the solution let's consider the mechanism of desertification initially. In general even in the desert area, underground water exists as shown in Figure 1. Now in our main area of afforestation activity at Alashan Meng in China's Inner Mongolia Autonomous Region, a part of Gobi desert, the underground water is about 100 m deep. Now the level, however, becomes deeper to reach 150 m in depth in some area because wells for irrigation are dug deeper and deeper year after year.

The underground water comes up towards the surface of the desert by capillary effect (Figure 1). Water goes up further by evaporation at the saturation vapor pressure. Thus the gradient of water concentration is generated from the deep part to the surface. At the Alashan area, the sand dune 30 to 50 cm deep contains 1% (w/w) of moisture, though the surface is perfectly dry.

In such conditions, a desert-plant scatters seeds on the dune-surface to leave a descendant. The seeds wait for rainfall though its annual quantity is 100 mm. With rainy arrival, the seeds begin to make rooting all at once. During the wet season, seeds elongate their roots as long as possible. Since the period is short, their roots usually grow to 10–20 cm in length, which is less than 30 cm that is long enough to reach the moisture part of the desert. In the next coming dry season, seedlings usually become dry and wither. Even if some seedlings were fortunately able to survive, they freeze to death in the next cold winter season when the temperatures usually drop to –20°C. Thus, seedlings have little chance to survive and the parent plant cannot leave descendants. In this way the area is denuded of vegetation and the desertification proceeds.

If the root can reach to the moisture part in the depth of 30–50 cm during wet season, plants and seedlings can live through the dry season. They can survive even in the cold winter because the deeper root does not freeze to death. Goats cannot gobble up the whole plants, either. In the next spring, they grow sprouts and during wet season the descendants grow larger with longer and fatter roots. The process rotates repeatedly and the surface of the desert is covered with vegetation to stop the outbreak of the yellow sand. The surface temperature becomes milder with plants and grasses. It calls for clouds and precipitations, which penetrates into the soil and raise the level of the underground water.

Figure 1. A Mechanism of Desertification and Its Rehabilitation



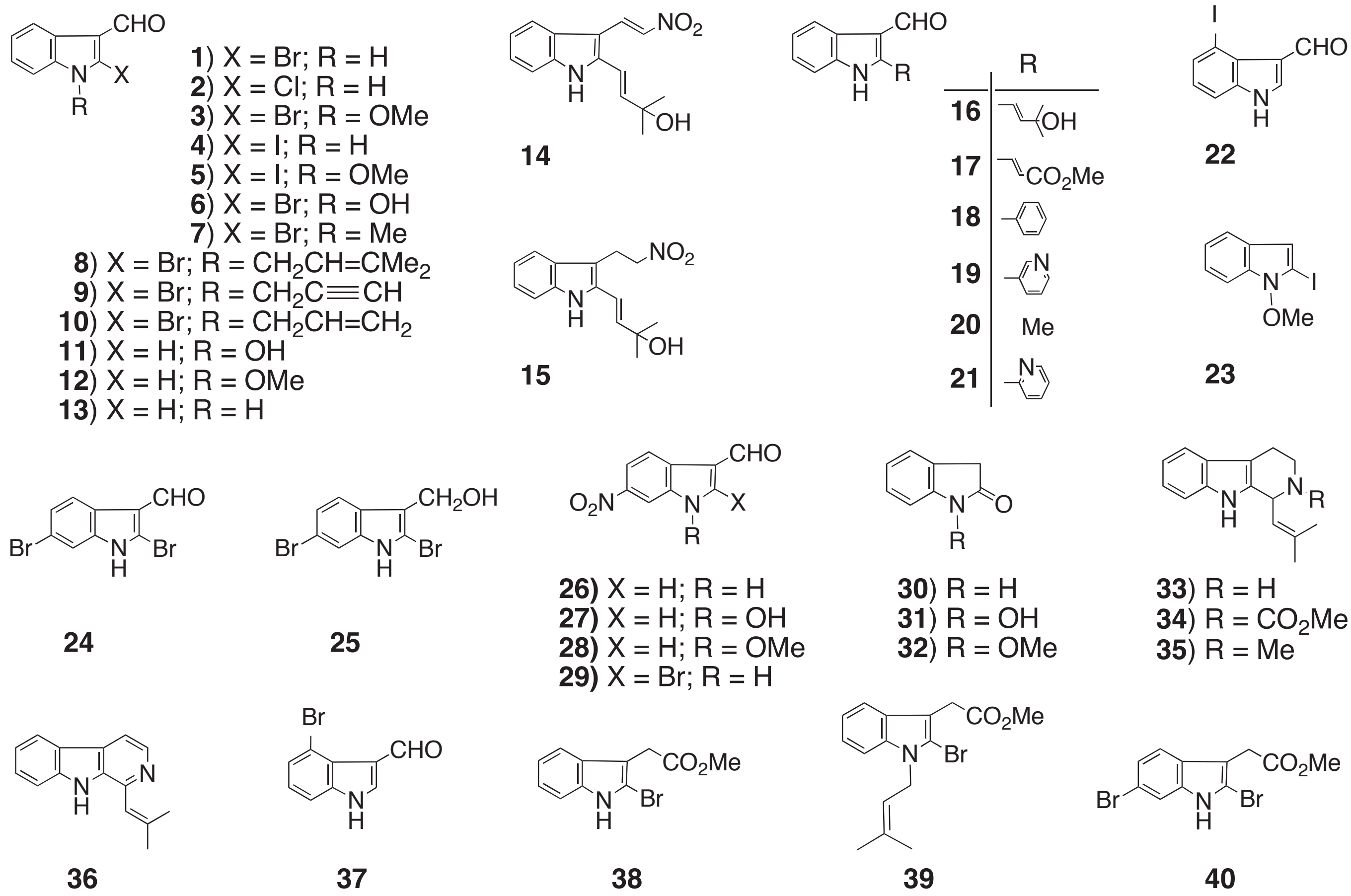
On the basis of the above analysis, we conceived that the key solution of the problem is the creation of a new root growth regulator, especially root growth promoter, which has the ability to help plants to elongate their roots two times longer than the original ones. The promoter would have a possibility to solve the worldwide food shortage[2] by supplying increased quantity of root vegetables, and also to solve the energy problem by enabling a greater mass of cultivation of bio-energy crops. In the long run the promoter would have benefit to the recovery from desertification.

3. SOMRE compounds

3-1. Discovery

Initially we have synthesized various derivatives[3] of indole-3-acetic acid (IAA) and related 4-substituted indole compounds[4] based on the fact that IAA is known as a plant growth regulator. On the other hand, we conceived 1-hydroxyindole hypotheses,[5] that led us to an idea that the non-toxic metabolites of tryptophan, an essential amino acid in our body, should have the expected biological activity. While acquiring experiences we have focused our research to indole-3-carbaldehyde[6] and indole-3-carboxylic acid,[6] and finally discovered that various types of derivatives of indole-3-carbaldehyde have the activity for regulating and/or promoting the growth of plant root. We named them SOMRE compounds[7] after the following three words, Somei, root, and elongation. SOMRE compounds consist of 40 members and their structures are shown in Figure 2.

Figure 2. SOMRE Compounds, No.1 — 40



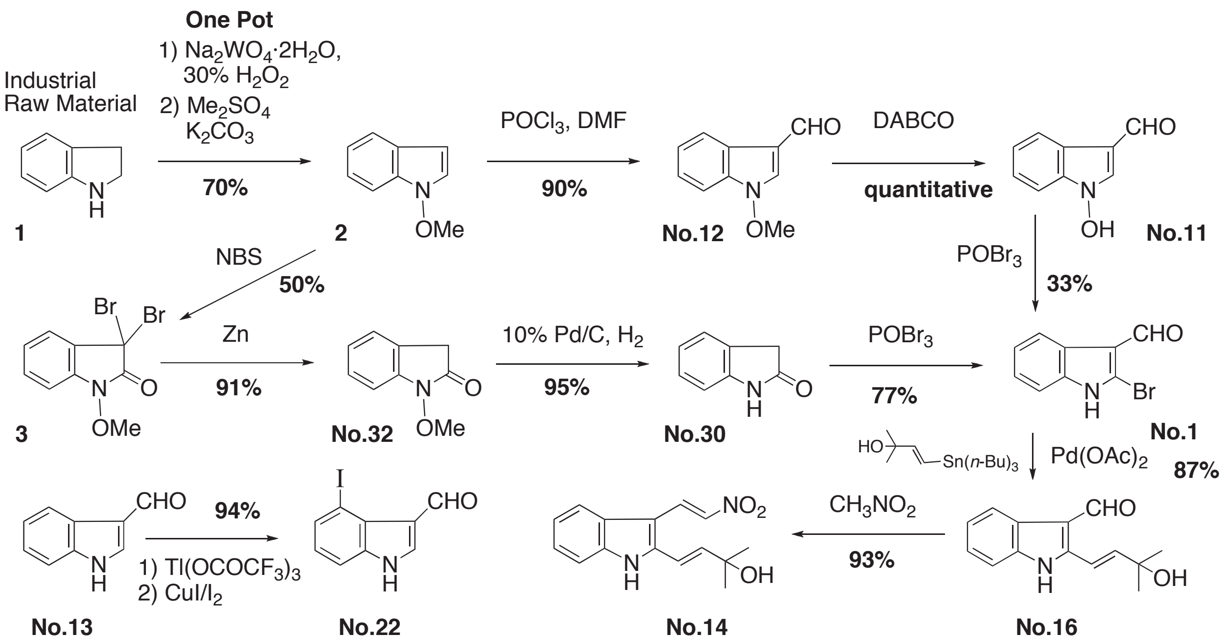
3-2. Synthesis

Of the 40 SOMRE compounds, synthetic routes to typical SOMRE compounds, which appear in this brief review, are shown in Scheme 1. Other compounds are prepared according to our previous reports.[8] SOMRE No. 1, No. 14, and No. 16 are prepared economically starting from 2,3-dihydroindole (**1**), an industrial raw material. Thus, **1** was converted to 1-methoxyindole (**2**) in 70% yield. This process was not possible without creating our original 1-hydroxyindole chemistry.[5] Subsequent Vilsmeier reaction of **2** with $POCl_3$-DMF provided 90% yield of 1-methoxyindole-3-carbaldehyde (SOMRE No. 12), a radish phytoalexin.[8] Ether cleavage of No. 12 was successfully carried out by our new reaction using DABCO as a nucleophile to give 1-hydroxyindole-3-carbaldehyde (SOMRE No. 11), which was further led to 2-bromoindole-3-carbaldehyde (SOMRE No. 1) in 33% yield by treatment with $POBr_3$.

An alternative route to SOMRE No. 1 was also developed from **2**. Treatment of **2** with NBS afforded 3,3-dibromo-1-methoxy-2-oxindole (**3**) in 50% yield. Reductive debromination of **3** with zinc/AcOH provided 1-methoxy-2-oxindole (SOMRE No. 32) in 91% yield, which was then converted to 2-oxindole (SOMRE No. 30) in 95% yield by the catalytic hydrogenation with 10% Pd/C. Finally SOMRE No. 30 afforded No. 1 in 77% yield by the treatment with $POBr_3$.

Improved Stille reaction[8,10] of SOMRE No. 1 with tributyl(3-hydroxy-3-methyl-1-butenyl)tin in the presence of n-Bu_4NCl provided 87% yield of SOMRE No. 16, which was then converted to SOMRE No. 14 in 93% yield by nitroaldol reaction. On the other hand, 4-iodoindole-3-carbaldehyde (SOMRE No. 22) was produced from indole-3-carbaldehyde (SOMRE No. 13) by the treatment with thallium tris(trifluoroacetate), followed by the reaction of the resultant (3-formylindol-4-yl)thallium bis(trifluoroacetate) with I_2/CuI in 94% yield.[11]

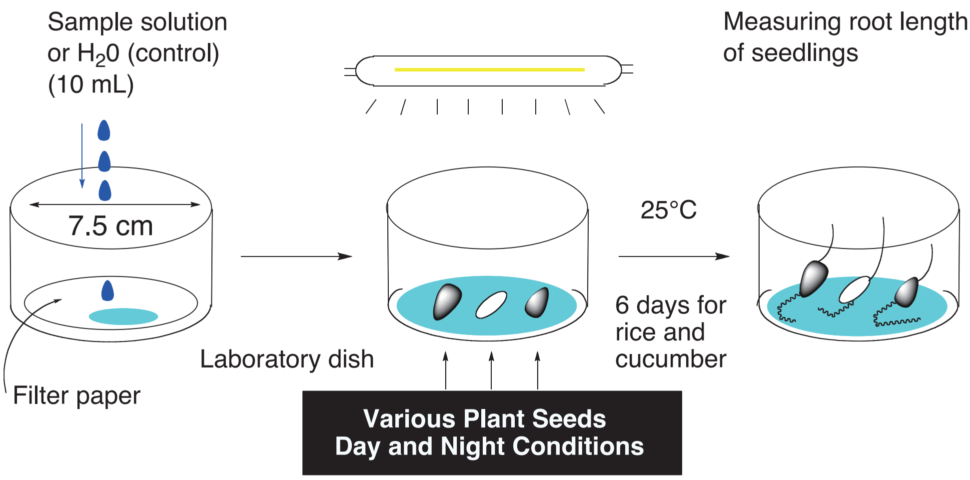
Scheme 1. Synthesis of SOMRE Compounds that Appears in This Review



3-3. Biological evaluation method for regulating the growth of root

Biological evaluation of SOMRE compounds was carried out as follows. Laboratory dish of 7.5 cm

Figure 3. Biological Evaluation Method of SOMRE Compounds



diameter with a filter paper inside was prepared (Figure 3). A 10.0 mL of sample solution or water (control) was poured into it. Generally speaking, 5 to 30 seeds were placed on the filter paper and kept growing at room temperature under day and night conditions. After a week, root length of each seedling was measured and compared with that of control.

In the case of seedlings (tomato and bean), 3 to 6 whole pots were immersed into a sample solution or water (control) for 1 h. They were then transplanted to a garden. After harvesting, numbers, weights, and tastes of the crop were examined.

4. Preparation of SOMRE solutions and their storage

4-1. A preparation method for 1.0, 0.1, 0.01, and 0.001 ppm aqueous solutions of SOMRE No. 1

Solubility of SOMRE No.1 to water is sparing. So, 1.0 mg of SOMRE No. 1 was put into about 200 mL of hot water[12] (70–80 °C) and dissolved completely with shaking. Then warm water[12] (40–50 °C) was added with shaking until the whole volume became 1.0 L. After the whole returned to room temperature, it can be used as a 1.0 ppm aqueous solution of SOMRE No.1. Plant roots or seeds can be soaked into it. Thirty minutes to 1 h is enough time for soaking. Longer time is needed for seeds with hard hull.

A 0.1 ppm aqueous solution of SOMRE No.1 is prepared as follows. With shaking warm water (40–50 °C) was added to a 100 mL of the 1 ppm aqueous solution of SOMRE No. 1 until the whole volume became 1.0 L. Diluting the 0.1 ppm aqueous solution of SOMRE No. 1 following the above procedure provides a 0.01 ppm aqueous solution of SOMRE No.1. A 0.001 ppm solution is obtained as well.

4-2. A preparation method for ethanol containing aqueous solutions of SOMRE No. 1

Ethanol can be used as a solubilizing agent of SOMRE No. 1. Thus, a 10.0 mg of SOMRE No. 1 was dissolved into 1.0 mL of warm ethanol.[13] The resultant solution was added to about 2.0 L of hot water (65–70 °C) with shaking. Then warm water (40–50 °C) was added with shaking until the whole volume became 10.0 L. After the whole returned to room temperature, it can be used as an ethanol containing 1.0 ppm aqueous solution of SOMRE No. 1. Ethanol containing aqueous solutions of 0.1, 0.01, and 0.001 ppm can be prepared by dilution using warm water according to the procedures shown in section **4-1**.

4-3. Storage

The aqueous solutions of SOMRE No. 1 prepared in section **4-1** can be stored for a few years under ordinary temperatures. Do not keep them in the refrigerator because SOMRE No. 1 sometimes precipitates under 15 °C and the concentration changes. In this case, reheating the solution to around 80 °C is necessary for dissolving them. Storage under direct sunlight is not recommended because ultra-violet rays gradually decompose SOMRE No. 1.

4-4. Preparation of other SOMRE solutions

Both aqueous and ethanol containing solutions of other SOMRE compounds can be prepared using the respective SOMRE compounds according to the procedures described in **4-1** and **4-2**.

5. Safety of SOMRE No.1 solution

SOMRE No. 1 is composed of non-toxic two substances, indole-3-carbaldehyde and bromide. The former is one of the metabolite of tryptophan and the latter is also a minor internal ingredients. Therefore, we could consider SOMRE No. 1 as a kind of organic nourishment agent and safe compound.

In addition, it is used under concentration of 1.0 ppm aqueous solution. The solutions are safe to skin and body. A goat had drunk the 1.0 ppm solution for 1 year in Gobi desert without any troubles in health. Rabbits and mice seem to like eating buds and roots grown by SOMRE No. 1. These are one of the problems for greening the desert.

6. Application of aqueous SOMRE compounds to various plants

6-1. Rice (Nihonbare) and cucumber (Sagamihanpaku)[14]

SOMRE compounds help seedlings extend roots in both rice and cucumber cases. The former is used as a representative of monocotyledonous plant and the latter a representative of dicotyledonous plants. As shown in the photograph (Figure 4), a 3 ppm aqueous solution of SOMRE No. 1 lengthened the root of rice (Poaceae) longer than that of the control.

Figure 4. Rice Nihonbare

Control ↑ SOMRE No.1 ↑ (3 ppm)

The data are summarized in Table 1. In the case of rice, average root length of control was 46.8 mm (100%). While the average root length of SOMRE varied a great deal depending on its concentration. Thus employing SOMRE No. 1 as 50, 12.5, 3, and 0.8 ppm aqueous solution, the average root lengths were 14, 140, 168, and 130%, respectively, compared with the control. The maximum length was achieved at the concentration of 3 ppm. When SOMRE No. 16 and No. 14 were employed, the average root length was longest at the 50 ppm concentration achieving 146 and 168%, respectively.

In the case of cucumber, interestingly SOMRE No.1 was not so effective. At the concentration of 3 ppm, the average root length became 113% compared to the control. Similar results are observed in the use of SOMRE No. 16. However, when SOMRE No. 14 was employed at the concentration of 3 ppm, the average root length was 190%, about two times longer than that of the control.

Above results are easy to understand when these data are expressed in such line graphs as Figures 5 and 6. A vertical axis represents relative average root length compared with the control (100%), while horizontal axis means concentration of aqueous SOMRE solution. As can be seen from Figure 5, at 3 ppm among other concentrations SOMRE No. 1 attains the top length of average rice root. For the root growth of cucumber, Figure 6 clearly demonstrates that the 3 ppm aqueous solution of SOMRE No. 14 is the best among other SOMREs and their concentrations.

Table 1. Average Root Length of Rice and Cucumber Effected by Aqueous SOMRE Compounds Depending on Their Concentrations

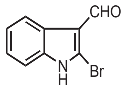
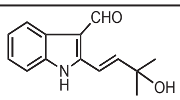
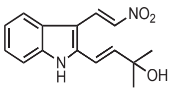
Plant and Root Length of the Control / Sample	Rice (Nihonbare) Control: 46.8 mm (100%)				Cucumber (Sagamihanpaku) Control: 12.1 mm (100%)			
	Concentration of Aq. SOMRE (ppm)				Concentration of Aq. SOMRE (ppm)			
	50	12.5	3	0.8	50	12.5	3	0.8
 SOMRE No.1	14	140	**168**	130	100	105	**113**	98
 SOMRE No.16	**146**	136	120	100	100	100	**118**	101
 SOMRE No.14	**168**	133	113	109	120	180	**190**	114

Figure 5. Average Root Length of Rice Nihonbare (Poaceae) Effected by Aqueous Solution of SOMRE Compounds Depending on Their Concentrations

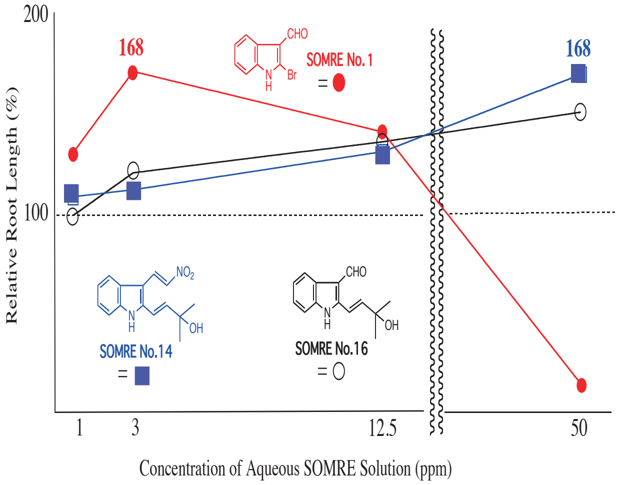
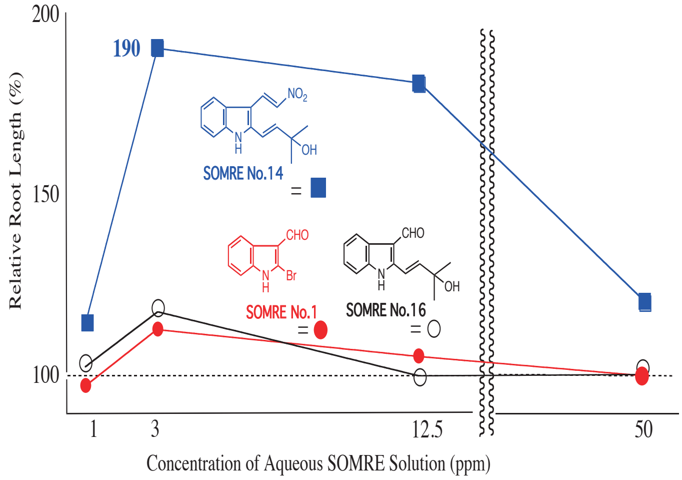


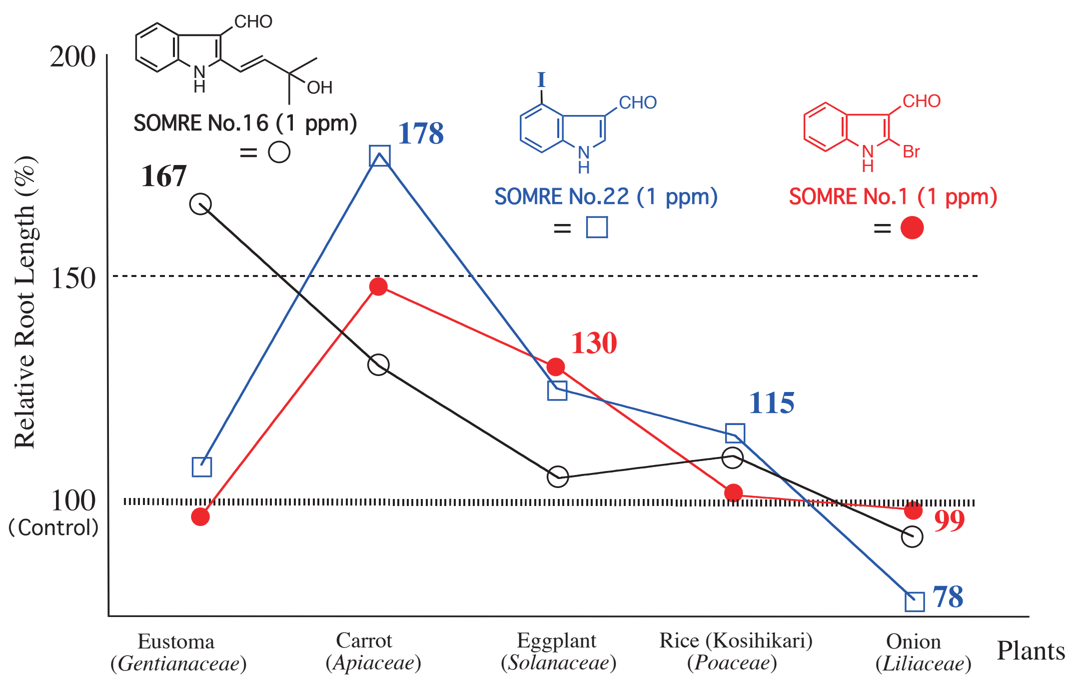
Figure 6. Average Root Length of Cucumber (Cucurbitaceae) Effected by aqueous Solution of SOMRE Compounds Depending on Their Concentrations



6-2. Eustoma (Gentianaceae), carrot (Apiaceae), eggplant (Solanaceae), rice (Poaceae), and onion (Liliaceae)[15]

Effects of 1 ppm aqueous solutions of SOMRE No. 1, No. 16, and No. 22 were examined upon the root growth of various plant seeds. The results are summarized in Figure 7, where a vertical axis represents relative average root length compared with the control (100%), while horizontal axis means plant species. When eustoma is chosen as test seeds, No. 16 is the most effective. Average root length reached to 167% longer than the control (100%). In the case of carrot, effect of No.16 dropped to 130% while the effect of No. 22 increased to 178% times longer than the control. If the eggplant is employed, No.1 is the best promoter among three SOMREs. It is worthy to mention that in the case of rice (Koshihikari), No. 22 again gives better results than No. 1 and No. 16. The effect of No. 1 decreased to 103%. This is a surprise result considering that its effect upon rice (Nihonbare) was 168% as shown in **6-1** section. When onion is examined, 1 ppm solutions of all tested SOMREs gave poor results than the control.

Figure 7. Effects of Aqueous 1 ppm Solution of SOMRE Compounds upon the Root Growth of Various Plant Seeds



6-3. Biodiesel plant, *Jatropha curcas* (Euphorbiaceae)[15]

Nowadays, *Jatropha curcas* attracts much attention as vegetable biodiesel fuel and it is believed to save the future shortage of energy. Five seeds in each laboratory dish were dipped into 1 ppm aqueous SOMRE No. 1, No. 4, and water (control), respectively, on Sept. 20, 2007 and the results are summarized in Table 2. The day of germination of control, SOMRE No. 4, and No. 1 was Sept. 24, 23, and 22, respectively. It is clear that SOMRE No. 1 quicken the day of germination compared with the control.

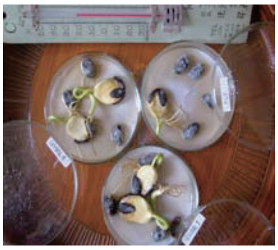
Germination rate is also improved as shown in Figure 8a. Germinated seeds were transplanted to a planter. On Nov. 6, SOMRE treated plants are growing bigger than the control (Figure 8b). However, during cold winter season, they all froze to death.

Table 2. Germination of *Jatropha curcas* (Euphorbiaceae)

	Day of Germination	Germination Rate on Sept. 26. (%)
Control	Sept. 24 (4 days after soaking)	20%
SOMRE No.1	**Sept. 22 (2 days after soaking)**	**40%**
SOMRE No.4	**Sept. 23 (3 days after soaking)**	**40%**

Figure 8

a)



b)

Sept. 20−Sept. 26, 2007, 25−30 °C, day and night conditions.

6-4. Turnip (*Brassica rapa*)[16]

Seeds of turnip (Hakurei) were dipped into 1 ppm aqueous solution of SOMRE No. 1 and water (control), respectively, for 30 min. They were sowed to a field on April 3, 2010 and cultivated under natural conditions. On May 22, they were harvested and the results are shown in Table 3. It clearly demonstrated that SOMRE No. 1 is effective upon the growth of turnip. Average weights of whole vegetable and bulb-shaped part are 139 and 141%, respectively, compared to those of the control.

Table 3. Crop of Turnip (Hakurei)

	Average Weight of Whole Plant (%)	Average Weight of a Bulb Part (%)
Control	190 (100%)	136.5 g (100%)
SOMRE No.1 1.0 ppm	**263.4 (139%)**	**192.5 g (141%)**

6-5. Potato (*Solanum tuberosum*)[16]

Potato of two species, Touya and May Queen, were cut into parts with a single bud. Each bud of the seed potato was dipped into 1 ppm, 0.1 ppm aqueous solution of SOMRE No. 1, and water (control), respectively, for 30 min. After dusting the cutting surface with wood ash, the resulting seed potatoes were dried and planted to a field on March 12, 2010, and cultivated under natural conditions. On June 26, they were harvested and the results are shown in Tables 4 and 5. In the case of species, May Queen, the average number and weight per one seed potato increased to 109 and 106%, respectively, compared to those of control (Table 4). It should be stressed that in the case of Touya, 0.1 ppm aqueous solution of SOMRE No. 1 demonstrated amazing effect on the growth and crop. Both the average number and weight of potato per one seed potato increased up to 200 and 149%, respectively (Table 5).

Table 4. Crop of Potato (May Queen) per One Seed Potato

	Average Number of Potato (%)	Average Weight of a Potato (%)
Control	11 (100%)	26.1 g (100%)
SOMRE No.1 1.0 ppm	12 (109%)	20.0 g (78%)
SOMRE No.1 0.1 ppm	**12 (109%)**	**27.7 g (106%)**

Table 5. Crop of Potato (Touya) per One Seed Potato

	Average Number of Potato (%)	Average Weight of a Potato (%)
Control	4 (100%)	126.7 g (100%)
SOMRE No.1 1.0 ppm	4 (100%)	133 g (105%)
SOMRE No.1 0.1 ppm	**8 (200%)**	**188.5 g (149%)**

6-7. Summary of the section 6

Judging from the results obtained in **6-1** and **6-2** sections, we can conclude that there exists a suitable concentration for each SOMRE compounds to help roots grow the longest. The findings in **6-2** section show that different plants require a specific SOMRE compound for their own, respectively, for attaining maximum root growth. Even if the plant belongs to the same family, the different species needs different SOMRE as a suitable root promoter, as demonstrated in the cases of rices, Nihonbare vs. Koshihikari, and potatoes, May Queen vs. Touya.

Therefore, before application of SOMRE compounds to plants and seeds, we should first find out the specific SOMRE compound and its suitable concentration for themselves.

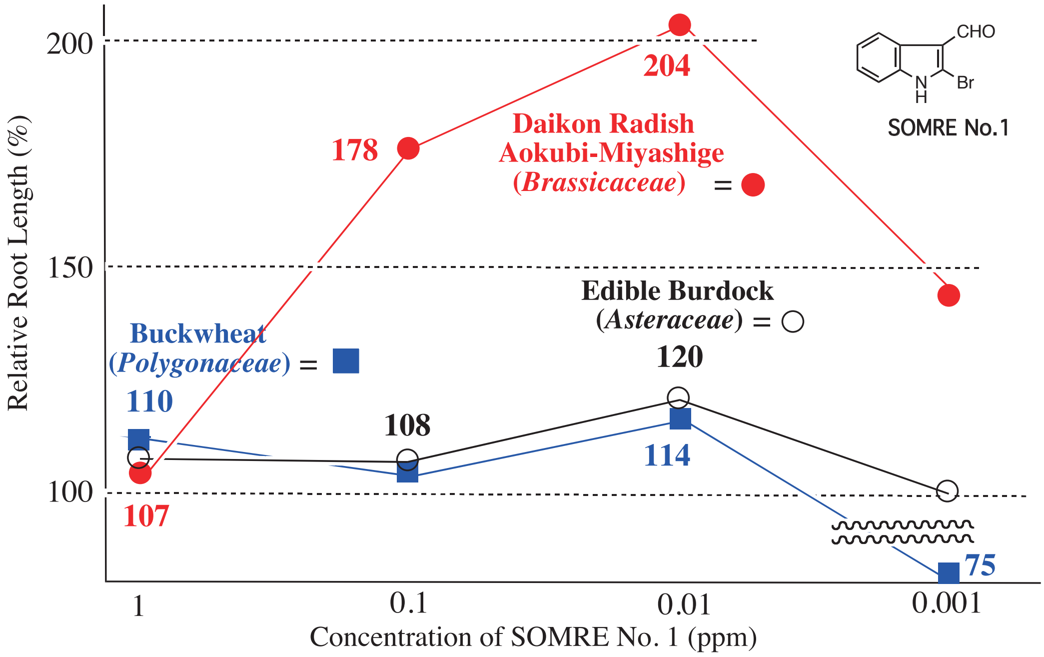
7. Application of ethanol containing aqueous solution of SOMRE No. 1 to various plants

In this section, an ethanol containing aqueous solution of SOMRE is introduced. Since SOMRE compounds are lipid-soluble materials, it is easy to make an ethanol containing solution than making ethanol-free solution. However, an application range of an ethanol free aqueous SOMRE is wider than the ethanol containing one because an ethanol is sometimes not suitable to some kinds of plant. Ethanol content is a crucial factor, too. The followings are successful examples.

7-1. Daikon radish (Brassicaceae), edible burdock (Asteraceae), and buckwheat (Polygonaceae)[16]

The effects of an ethanol containing aqueous solution of SOMRE No. 1 upon seeds are summarized in Figure 9. A vertical axis represents relative average root length compared with the control (100%), while horizontal axis means concentration of SOMRE No. 1.

Figure 9. Average Root Length of Plants Effected by Ethanol Containing Aqueous Solution of SOMRE No. 1 Depending on Concentration



Daikon Radish, Aokubi-Miyashige, is a typical example and shown in solid circle and line. Average root length reaches top length, 204% longer than the control, at the concentration of 0.01 ppm. Similarly, at the same concentration (0.01 ppm), edible burdock (shown in circle) and buckwheat (shown in solid square) demonstrated the peaks, 120 and 114%, respectively.

7-2. Soybean (Fabaceae)[16]

In the case of soybean, seedlings in a pot were dipped into a 1 ppm ethanol containing solution of SOMRE No. 1 for 1 h, then transplanted to a field, and cultivated from June 7 to Aug. 16, 2009. The crop of soybean per one stem is shown in Table 6.

Average numbers of shells and peas in a shell, obtained from SOMRE treated seedlings, are clearly better than those of the control. The former reaches 153% and the latter 106%. Consequently, total number of peas increased to 162% compared with that of the control. The SOMRE treated peas tasted better than that of the control.

Table 6. Crop of Soybean (Fabaceae) per One Stem

	Average Number of Shells (%)	Average Number of Peas in a Shell (%)	Total Number of Peas (%)
Control	33.6 (100%)	1.8 (100%)	61.6 (100%)
SOMRE No.1	**52.0 (153%)**	**1.9 (106%)**	**100.0 (162%)**

Taste of peas produced by using SOMRE No.1 is better than that of the control.

7-3. Tomato (Solanaceae)[16]

Three pots of tomato seedlings were dipped into a 1 ppm ethanol containing solution of SOMRE No. 1 for 1 h, then transplanted to a field and cultivated from April 30 to Sept. 16, 2009. The crop of tomato per one stem is shown in Table 7. It is interesting to note that the average number of tomato fruit, obtained from SOMRE treated plants, is demonstrated to be almost double (188%) of the control. While 110% increase in the average weight of each fruit was observed compared to those of the control.

Table 7. Crop of Tomato (Solanaceae) per One Stem

	Average Number of Fruit (%)	Average Weight of a Fruit (%)
Control	10.6 (100%)	114 g (100%)
SOMRE No.1	**20.0 (188%)**	**125 g (110%)**

Taste of fruits produced by using SOMRE No.1 is better than that of the control.

Table 8. The Height and Girth of Tomato Plant

	Average Height of Tomato Plant	Average Girth (cm) of Stem at the Part 1.0 m above the Ground (%)	Girth (cm) of Root at the Part [X cm] Deep below the Ground
Control	265(100%)	4.33 (100%)	1.8 [27.5] 1.5 [29.4] 1.7 [25.5]
SOMRE No.1 (Ethanol Containing, 1 ppm)	**381.6 (144%)**	**6.0 (140%)**	1.7 [41.0] 2.8 [53.5] 2.7 [83.5]

The increase in the crop was identified due to the healthy, fatter, and longer roots. Table 8 shows the girth of root at the part [X cm] deep below the ground. Girth of three control plants are 1.5–1.8 cm in around

27 cm depth. On the other hand, three SOMRE treated ones are 1.7–2.8 cm in more than 40 cm depth. Average height and girth of stem at the part 1 m above the ground increased to 144 and 140%, respectively. These are the reasons why tomato fruits, grown by the use of SOMRE, were sweeter than the control ones.

7-4. Japanese black pine (*Pinus thunbergii*)[17]

Japanese black pine is known to tolerate pollution and salt damage. It is therefore employed all over Japan, especially for conservation of coastline, as windbreak and tide prevention trees. As a result, a greater number of its seedlings are needed for planting. The headache is, however, the low rate of raising seedling from seed. Improving the rate is now a challenging problem.

We applied ethanol containing aqueous solution of SOMRE No. 1 to the seeds of Japanese black pine and cultivated them between April 28 and May 8, 2007. The results are summarized in Table 9. As expected, the germination rate and average root length varied depending on the concentration of SOMRE No.1. As the concentration became diluted, the former reached to 100% at 0.05 ppm. It should be noted that the most diluted 0.001 ppm solution is a powerful and assured promoter for root elongation, achieving 449% compared to the control. Based on these results, we sowed a few seashores with black pine seeds, pretreated with SOMRE No. 1. The test is now under observation.[17]

Table 9. Germination Test of Japanese Black Pine with Ethanol Containing Solution of SOMRE No. 1

	Control	SOMRE No.1 1 ppm	SOMRE No.1 0.05 ppm	SOMRE No.1 0.001 ppm
Average Root Length (mm) [%]	6.1 [100]	9.8 [160]	**10.4 [170]**	**27.4 [449]**
Germination Rate (%)	86	71	**100**	**100**

8. Combating desertification with SOMRE No. 1 and future planning

We have created SOMRE compounds as root promoters with the ability to make roots grow two times longer than usual. Therefore, we expected that they would meet our dream to change desert green tract, by making the roots of wild grasses and plants in Gobi desert reach to the moisture part under the flow dune surface, and by consequently making them survive through years.

8-1. Watermelon in Kalahari Desert, Africa[14]

In Kalahari desert, wild watermelon plays an important role for a local people as resources to get precious water. With an aim to increase the crop, we tried germination test using watermelon seeds from Kalahari desert. Table 10 summarizes the results employing aqueous solution of SOMRE No. 1. The experiment was carried out between Aug. 19−Aug. 25, 2007 under day and night conditions. On Aug. 23 seeds germinated at a time. Figure 10a is the photo taken on Aug. 24. The seedlings were grown until Aug. 25 and then transplanted to a field.

On Nov. 28, fruits were harvested and shown in Figure 10b. The left edge is the fruit harvested from the control. The second and third fruits from the left are obtained from seeds treated with 1 ppm solution of SOMRE, while the first and second ones from the right are from seeds treated with 0.1 ppm solution.

It is evident that 1 ppm solution of SOMRE No. 1 helps germination and growth, effectively. Consequently healthy fruits were obtained.

Applications of SOMRE to various wild plants, grains, and edible plants would have the possibility to help people in Kalahari desert to produce much foods.

Table 10. Germination of Watermelon Seeds from Kalahari Desert Using Aqueous SOMRE No. 1

	Control	1 ppm	0.1 ppm	0.01 ppm	0.001 ppm
Germination Rate	20%	**100%**	60%	60%	60%

Figure 10

a) Aug. 24

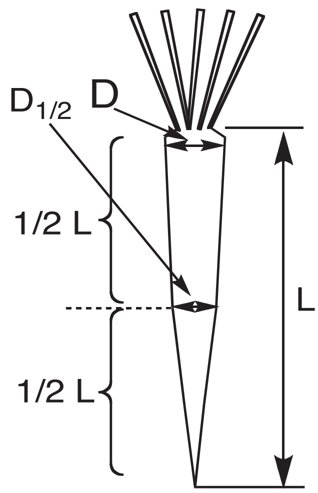
b) Harvested on Nov. 28, 2007. The left edge is the fruit from control. Te rest fruits are from SOMRE treated seeds.

8-2. Greening Gobi Desert, Inner Mongolia, China[5,7,8,13,14]

With our data shown in sections **6** and **7** in hand, we have performed 12 times of preliminary test for greening Gobi desert in Inner Mongolia from July 2005[18] to June 2010 with a cooperation of NPO groups and the local government. We applied aqueous solution of SOMRE No. 1 to the seeds of wild plants, such as *Hed ysarum scoparium* (Fisch et C.A. Mey**)** and *Calligonum alaschanicum* (a kind of sand jujube) at Gobi desert, and tried their root elongation test repeatedly.

In the typical trial, seeds of *Calligonum alaschanicum* were divided into 5 groups. Each group was dipped into 1, 3, 10 ppm aqueous solutions of SOMRE No. 1, a 2 ppm aqueous solution of IAA (the reference), and H_2O (the control), respectively, for 30 min. Experiment farmland was divided into 5 equal parts as well. Seeds of each group were separately sprinkled to the divided farmlands on ditches of 5 cm deep and they were covered with sand. They were brought up for 73 days (from August 2 to October 14, 2005) under natural environment of the desert except for watering every one-week. We then dug out grown young plants and compared the average root length. The results are summarized in Table 11. It clearly shows that SOMRE No. 1 has a remarkable effect on the growth of native plant root. Especially at the concentration of 1 ppm, SOMRE No. 1 encouraged the plant to develop roots about 2.4 times longer, 4 times wider in diameter both at the top and half part of the root length, and 8 times heavier than those of the control, respectively.[19] The reference IAA gave poor results in accordance with other trials under various concentrations.

Table 11. Plant Growth for 73 Days at Gobi Desert in Inner Mongolia



Planting: August 2, 2005. Digging: October 14, 2005

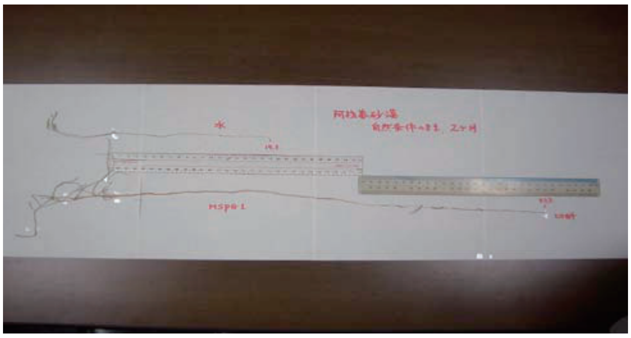
Root \ Sample	H_2O (Control)	IAA (reference) 2 ppm	SOMRE No.1 10 ppm	SOMRE No.1 3 ppm	SOMRE No.1 1 ppm
Length (**L** cm)	18.0	21.0	22.5	**36.0**	**42.5**
Width (**D** mm)	1.5	1.2	1.5	2.0	**6.0**
$D_{1/2}$ (mm)	1.0	1.0	0.8	2.0	**4.0**
Weight (mg)	620	310	360	**1,390**	**4,980**

With these successful results in hand, we continued preliminary field test without watering under natural conditions to make Gobi desert green. Our compounds (SOMRE No. 1, No. 4, and related compounds) made the wild plant roots longer enough to reach the moisture part that exists in the depth of around 30−40 cm from the earth surface of the desert.[20]

In between May 2006 and April 2007, we confirmed that young plants, grown from the seeds of *Hed ysarum scoparium* treated with aqueous solution of SOMRE No. 1, had sufficient root length, three times longer (53.2 cm) than that of the control (19.1 cm) as shown in Figure 11. They survived without freezing to death through cold winter. They gave bud in next spring and proved to be able to survive through a year! Of course they are growing in June 2010.

Figure 11. The Results of Field Test under Natural Conditions without Watering

Above two: control. Root length is 19.1 cm each. →
Below: SOMRE treated root. Length is 53.2 cm. →

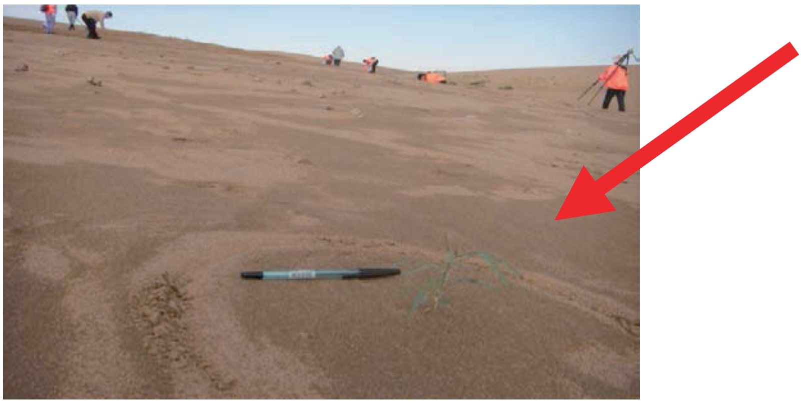


In April 2007, we dipped 2,700 seedling's roots of *Hed ysarum scoparium* into the 1 ppm aqueous solution of SOMRE No. 1 for 30 min and planted them to about 10 hectares of Gobi desert. Under natural environment without artificial watering we observed their growth. Two months later, their survival rate is 87.6%, much better than 78.3% of the control group.[21] They are growing bigger and fatter at present in June, 2010. The results are satisfactory. However, the problem is how on earth we could dig holes, sow seeds, and plant trees in global size. That is impossible!

Figure 12. Making Clay Dumpling. Inside are SOMRE Treated Seeds.

Figure 13. 127 Seedlings, Growing on the Surface of Flow Dune

A seedling of *Calligonumalaschanicum*



In the end of May 2007, the first trial in the world was carried out to throw 30,000 seeds while walking onto the 2 hectares of flow dune surface in Gobi desert. The seeds had been soaked in advance into a 1 ppm aqueous solution of SOMRE No. 1. After leaving them under natural conditions for two months, an impressive result was obtained at the beginning of August. The germinating rate was surprisingly more than 0.1% and 30 seedlings were growing.[22]

On May 17, 2008 in Gobi desert, we made clay dumplings containing pre-treated seeds inside with SOMRE No. 1, which consist of a 1:1 mixture of *Hed ysarum scoparium* and *Calligonum alaschanicum* (Figure 12). Again we threw 25,700 clay dumplings onto the 2 hectares of flow dune surface while walking. On October 5, 2008, we found 127 seedlings (about 1:1 mixture of *Hed ysarum scoparium* and *Calligonum alaschanicum*) were growing under natural conditions. The germination rate rose up to 0.5%[23] (Figure 13).

To our regret, the above small area with 127 seedlings was completely engulfed by large flow dune until the end of May 2009. The result suggests that sowing seeds to a wide area at a time is necessary.

8-3. Proposition for "the cure for the earth"

The results described in sections **8-1** and **8-2** demonstrate the possibility that the application of the SOMRE technology to a wide range of flow dune at a time by air plane could make the desert full of plant and grasses. The application would not be limited to Kalahari and Gobi deserts. The technique can be applied to all deserts in the world using seeds or seedlings of native plants. From these points of view, we have proposed the following concrete proposition (Figure 14) as “the cure for the earth” at the international Bio Forum, held in Tokyo in July 2008.[14]

Figure 14. A Concrete Proposition to Change Desert Back to Grassy Plain and to Stop Global Warming

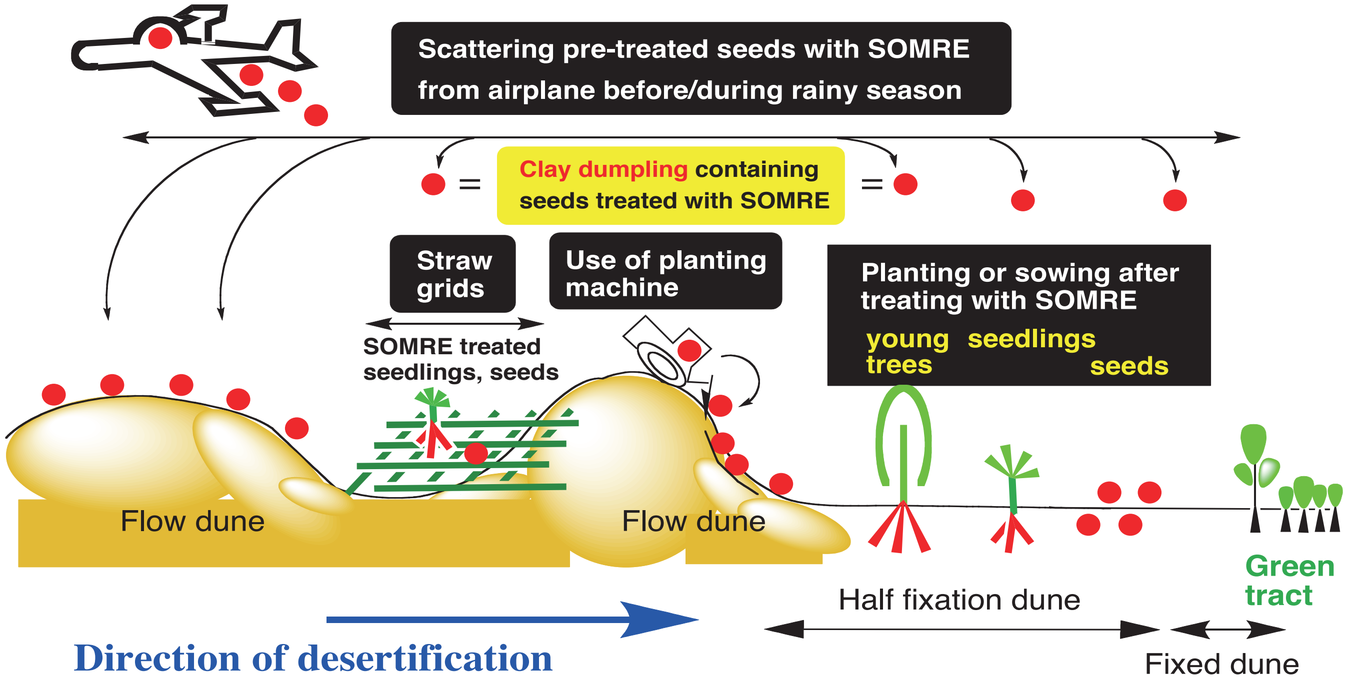


Figure 14 illustrates the situation that desertification proceeds to the right direction. The flow dune is completely denuded of vegetation. On the front of the flow dune, there develops half fixation and fixed dune, and the latter connects to the green tract of land.

A concrete proposition for "the cure for the earth" is the following. First of all, before or during rainy season, roots of young trees and seedlings, and seeds (of trees and grasses) are soaked into an aqueous SOMRE solution. Then, young trees are planted in a wide belt about 1 km apart from the front of the flow dune. Seedlings are next planted at the green tract side. Subsequently, seeds are sowed similarly. These three steps of placement is the method to check the advance of the flow dune. In addition, the straw grids that are wisdom of ancient people are set in many places in the flow dune. Above SOMRE treated young trees, seedlings, and seeds should be employed for planting or sowing in the straw grids. Furthermore, anyone can treat large area alone by employing tractor or planting machine.

The most effective method[14] is the aerial scatter of clay dumplings by airplane, containing SOMRE treated seeds inside. This technique could change a wide range of flow dunes into a half fixation dunes at one time. Repeating the above trials would result in turning wide area of desert to green lands and ending outbreak of yellow sand. In the near future, a lot of newly grown trees and grasses absorb a greater mass of carbon dioxide culminating in the stopping of global warming. Thus, we believe SOMRE compounds become “the medicine for the earth.”

8-4. Aerial scatter of seeds treated with SOMRE in Gobi desert[24]

According to our proposal, on June 20, 2010, employing airplane, we have carried out aerial scatter of 450 kg of seeds, about 1:7 mixture of *Hed ysarum scoparium* and *Calligonum alaschanicum*. The seeds were soaked in advance in 1 ppm aqueous solution of SOMRE No. 1 for 30 min, followed by drying in the sun. The scattered area is about 88 ha and it consists of flow and half fixation dunes. Follow-up duration is planned to be 4 years. Although this time we could not utilize clay dumplings, we hope the seeds grow and survive under severe natural conditions.

8-5. Plans for future

Applications of SOMRE compounds to sword bean, *Cryptomeria japonica* (Cupressaceae), Chinese medicine such as *Forsythia viridissima* (Oleaceae) and *Glycyrrhiza* (Fabaceae), are now in progress. Rubber trees, sugar canes, lawns, and endangered species are attractive targets remained to be examined. Cuttage and grafting are another subjects to be examined. If the SOMREs have activity to the exuberance of aquatic plants such as mangrove and reed, it would be beneficial for improving the marine environment. Application of SOMRE compounds to plants and grasses has no limits.

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He was born in 1941 in Chiba, Japan. He attended Tokyo University (1961-1970) and obtained his Ph D degree (1970) under the supervision of Professor Toshihiko Okamoto. He then moved to ITSUU Laboratory (1970–1976). After postdoctoral work (1975-1976) with Professor William G. Dauben (University of California, Berkeley), he was promoted to Associate Professor in 1976, full Professor in 1984, and retired in 2007. Now, he is Professor Emeritus of Kanazawa University. He received The Pharmaceutical Science of Japan (PSJ) Award for Young Scientists (1971), Kametani award (2001), and The PSJ Award for Educational Services (2006).
He proposed synthetic philosophy for evaluating the efficiency of organic synthesis. Based on the philosophy, his research interest has been focused on the indole chemistry for the creation of new biologically active compounds by developing and utilizing original chemistry. Consequently, he created IPAs, VEDs, BMs, and SOMREs as potential drugs for cerebral and myocardial infarctions, erectile dysfunction, osteoporosis, and root growth promotion, respectively. With SOMREs in hand, he has been active as his life work in production of root vegetables for aiming at stopping food shortage and in combating desertification at Alashan Meng in China's Inner Mongolia Autonomous Region, a part of Gobi desert.