Environmental Management by Using Weedy Plants

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ABSTRACT

The positive functions of aquatic and terrestrial weedy plants were reviewed in terms of water purification, soil erosion prevention, salt-affected soil utilization, etc.. Introduced were several examples to utilize weedy plants for environment management by exploiting their positive functions.

Key words : Weedy plant, Environment, Management, water purification, soil erosion

INTRODUCTION

In recent years environmental concern has focused on the degradation of the Earth's natural systems. Management arguments have been directed toward the actual impacts of human activity on natural environments and the means by which resources can be sustained[15]. The continuing destruction of the biosphere, the pollution of the atmosphere and water resources, and land degradation have attracted much attention. These global changes may produce their greatest effects by destabilizing natural habitats and leading to new environmental weed problems[3]. Of course, weeds are widely recognized as a major threat to food production. Yet how many people would recognize the grave threat that weedy plants pose to natural ecosystems?

Then we must be free from the traditional weed science. And coexistence with weedy plants, and furthermore, environmental management by using them must be considered as an important aspect of their management.

In this following sections, we will examine some characteristics of weedy plants, and introduce some measures to utilize their positive functions.

CONTRIBUTION OF WEEDY PLANTS

Aquatic plants are an essential feature of the aquatic ecosystem. The benefits they provide to the ecosystem include : ① The production of oxygen through photosynthesis, ② Cover for young fish so they can escape predation, ③ Sites for attachment by a number of organisms, ④ Protection against wave erosion and soil erosion of banks, ⑤ Food supply for wild life, including waterfowl, ⑥ Removal of nutrients from the water[4]. Most weedy aquatic plants share these functions.

Weedy aquatic plants may also have other functions, for example as livestock feed, mulch, green manure, compost or handicrafts They may also serve as ornamental plants, and add to the beauty and serenity of an aquatic landscape.

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a. Water purification function

The level of plant nutrients in many bodies of water has increased through discharges from urban and agricultural activities. The most desired of the water purification functions of weedy aquatic plants is their capacity for absorbing nitrogen and phosphorus. An efforts has been made in Japan to utilize weedy aquatic plants such as *Eichhornia crassipes* sp., *Pharagmites communis* and *Azolla* sp., since the remarkably rapid nutrient uptake of these plants has often been demonstrated[6]. The use of other species such as *Typha* sp., *Cyperus papyrus*, *Iris pseudacorus*, *Oenanthe javanica*, *Nasturtium officinale* in both natural and artificial land for wastewater treatment is estimated.

Artificial purification facilities :

One example is the artificial pilot plant-scale system introduced in Hinase, Okayama prefecture[6]. The system was designed to treat 25m^3 per one day of domestic sewage from about 30 houses, and to flow through trenches by overflow. The system consists of a stabilization trench covered with *Eichhornia crassipes*, and two lined trenches containing soil which are designed to contain weedy aquatic plants of 13 species. In addition, there are three catalytic oxidation trenches filled up oyster shells, fishing nets and bricks, respectively. Effective removal of COD, SS, N has been recorded, and a 92% reduction in total P. It was observed that *Iris pseudacorus* and *Elodea nuttallii* appear to show promise as having a particularly marked ability to accumulate N and P. Accumulation by *Oenanthe javanica* was higher during cooler seasons.

Resource-recycling system for domestic waste-water treatment using useful plants :

Recently, attention has been directed toward a kind of wastewater treatment system consisting of bed filter planted with useful plants because of the low cost and ease of operation, which is designated as plant rock filter, halophyte bed, macrophyte bed or root zone method[1,12,16]. It is important to add functions of resource recovery and reuse to such systems by selecting plants useful for human life.

An advanced treatment system to purify domestic wastewater in agricultural and mountainous areas were designed and constructed in Tsukuba, Ibaragi prefecture. This was made by combining a joint treatment plant and a bio-geofilter ditch planted useful plants on a zeolite-bed filter[16]. More than 30 species of plants, such as useful plants including Kenaf, Papyrus, vegetables, herbs, flowering plants and aquatic plants, have been investigated to clarify their purification characteristics. As a result, it became apparent that the average N concentration of the treated domestic wastewater, which is 10.88 mgL^{-1} by the bio-geofilter ditch in the summer period when Kenaf and Papyrus were effectively grown.

It was also reported that Papyrus with bed filter material (zeolite) was the most suitable plant due to the considerable increase of the N and P removal efficiency of the system, and maintenance of a high removal efficiency for a long period of time, and that Kenaf was also suitable because of its high wastewater treatment efficiency and importance as paper source[1].

At present, the similar advanced project on development of a resource-recycling system for water purification by utilizing absorption capacity of useful plants, funded by the Ministry of Agriculture, Forestry and Fisheries, is running. As a part of this project, our laboratory makes researches on selection and evaluation of emerged plants suitable for nutrient removal with a zeolite-bed filter[12]. *Hydrocotyle umbellata* was planted in polyester bags filled with zeolite, and cultured in nutrient enriched wasters with 20 ppm N and 5 ppm P contained in the tank for 4 days. After that, its treatment effluent supplied to each tank in which each emerged plant were stocked. The evaluated plants were *Hydrocotyle umbellata*, *H. verticillata*, *Oenanthe javanica*, *Nuphar japonicum* and *Persicaria conspicua*. Over 97% of the input NH_4-N was removed in each 4 days by the tank contained *Hydrocotyle umbellata* with zeolite due to high adsorption efficiency of zeolite, then in the subsequent each tank with each plant species, NH_4-N removal was not significantly different among plant species(Fig. 1). NO_3-N and PO_4-P removal, however, were found to be different among plant species. These removal were found to be more effective in *Hydrocotyle verticillata*, *H. umbellata* and *Persicaria conspicua* tanks, depending on their high growth rate, high nutrient accumulation in the plant tissue and little adsorption by zeolite in the first tank (Fig. 2 and Fig. 3).

b. function of preventing soil erosion in littoral region

It is generally said that large-sized emergent weedy plant have the function of reducing waves and binding mud with their underground rhizomes. according to the research by Oki(1995)[7], while the subterranean stems of *Pharagmites communis* are mostly distributed in the soil 40 cm deep or less, its roots reach the soil layers up to 60 cm deep. Many studies have confirmed the fact that the root system of *P. communis* is intertwined and fixed firmly to the soil, from which dense stems grow up to over 2 m every year and absorb wave energies.

Possibilities of vegetative cover with weedy plants on bare slope of a dammed reservoir :

Steep banks of dammed reservoir result in minimal littoral areas, and shores are often exposed by imposed fluctuating water levels, creating a barren littoral environment. In these areas, soil and water conservation using a vegetative technique has received attention.

A two year field investigation was conducted

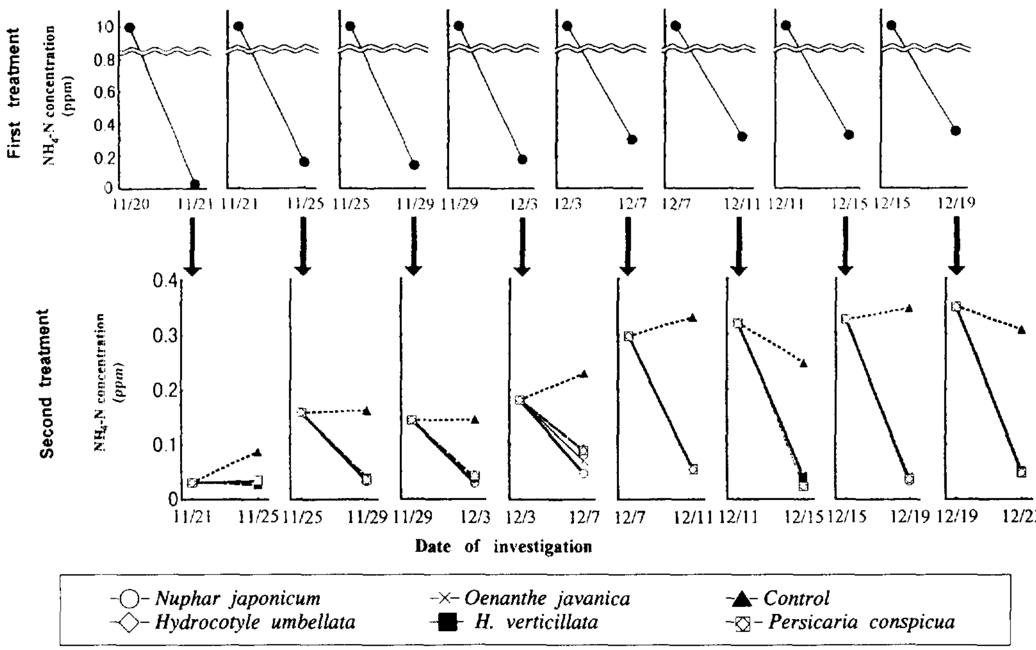

Fig. 1. Change in NH_4-N concentration according to a 4-day detention in each plant filter tank.[12]
First treatment : *H. umbellata* in bed filter(Zeolite) system
Second treatment : Water culture of each 5 plant species

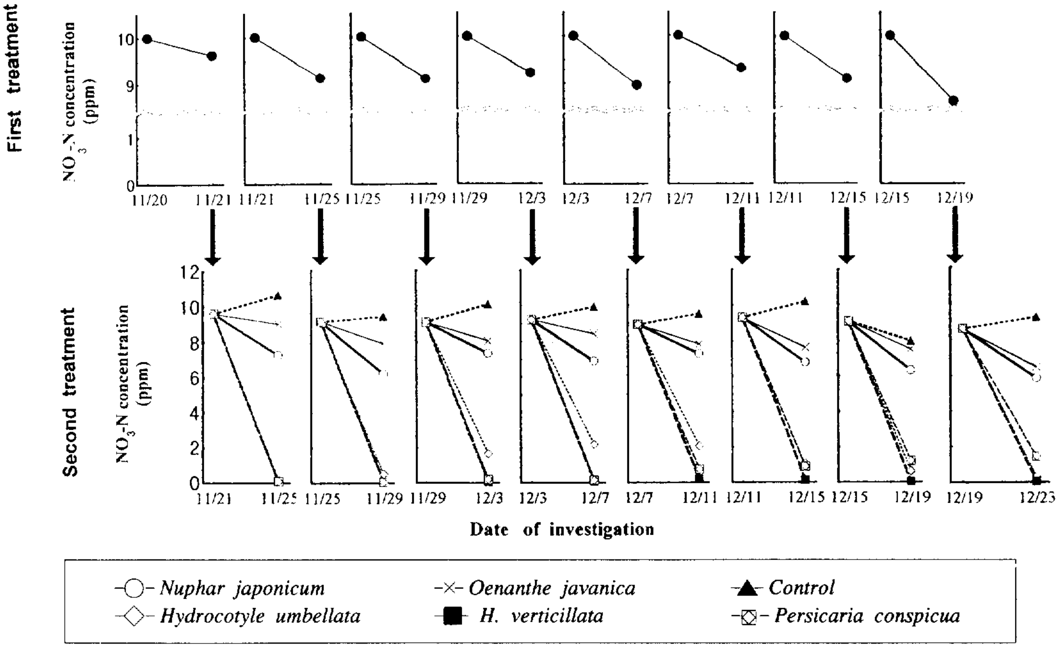

Fig. 2. Change in NO_3-N concentration according to a 4-day detention in each plant filter tank.[12)]
First treatment: *H. umbellata* in bed filter(Zeolite) system
Second treatment: Water culture of each 5 plant species

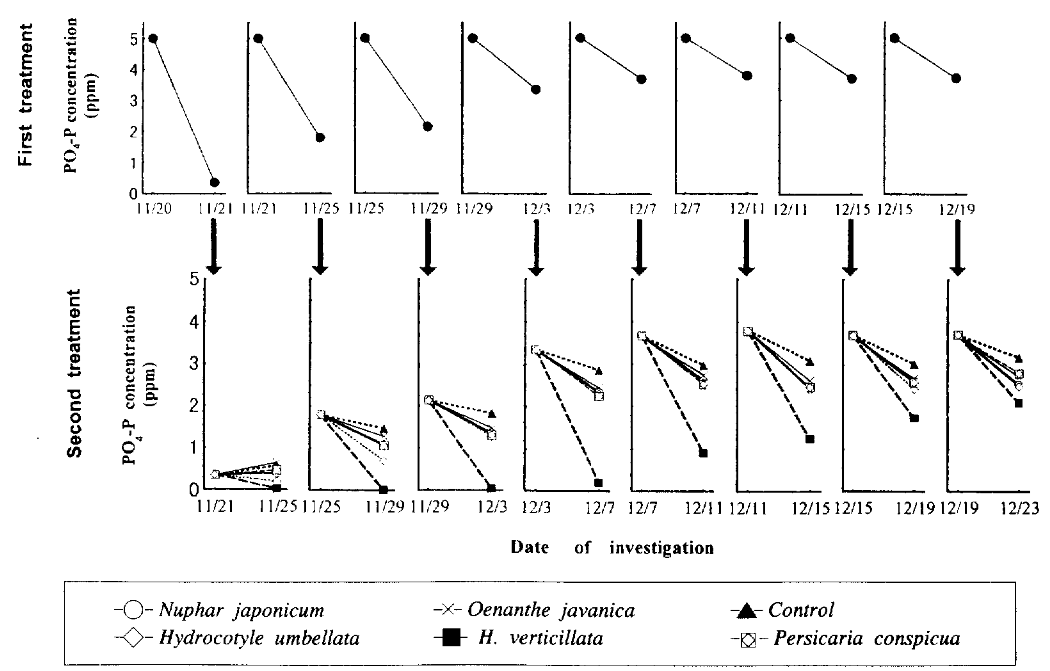

Fig. 3. Change in PO_4-P concentration according to a 4-day detention in each plant filter bank.[12)]
First treatment: *H. umbellata* in bed filter(Zeolite) system
Second treatment: Water culture of each 5 plant species

at the Sameura dammed reservoir located in Kochi prefecture, Japan, with the objective of selecting aquatic or amphibious weeds which has potential for surviving and forming vegetation on bare slopes[8]. *Paspalum distichum*, *Iris pseudacorus* and *Oenanthe javanica* showed good results. After the initial screening of suitable weedy plants, the effects of depth and duration of waterlogging on the survival ability of the three selected species were investigated. *P. distichum* and *I. pseuacorus* survived for 9 weeks under waterlogged conditions at a water depth of 2m, though water logging resulted in lower dry matter production(Table 1). *I. pseudacorusit* showed greater tolerance to water logging than *P. distichum*. In contrast, under an

Table 1. Effect of depth of submergence on final dry matter production.[8]

Treatment	*Paspalum disticum*	*Iris pseudacorus*
0 m (control)	100	100
1 m	80	83
2 m	79	79

Value represent index : Dry weight of plants grown in control=100
Investigation period : 9 weeks

unsaturated soil moisture condition(pF 2.1), shoot growth of *P. distichum* was less sensitive to soil moisture stress. It appears that the ability of these weedy plants to withstand given periods of the submergence and drought depends on plant physiology of the species. More informations of the

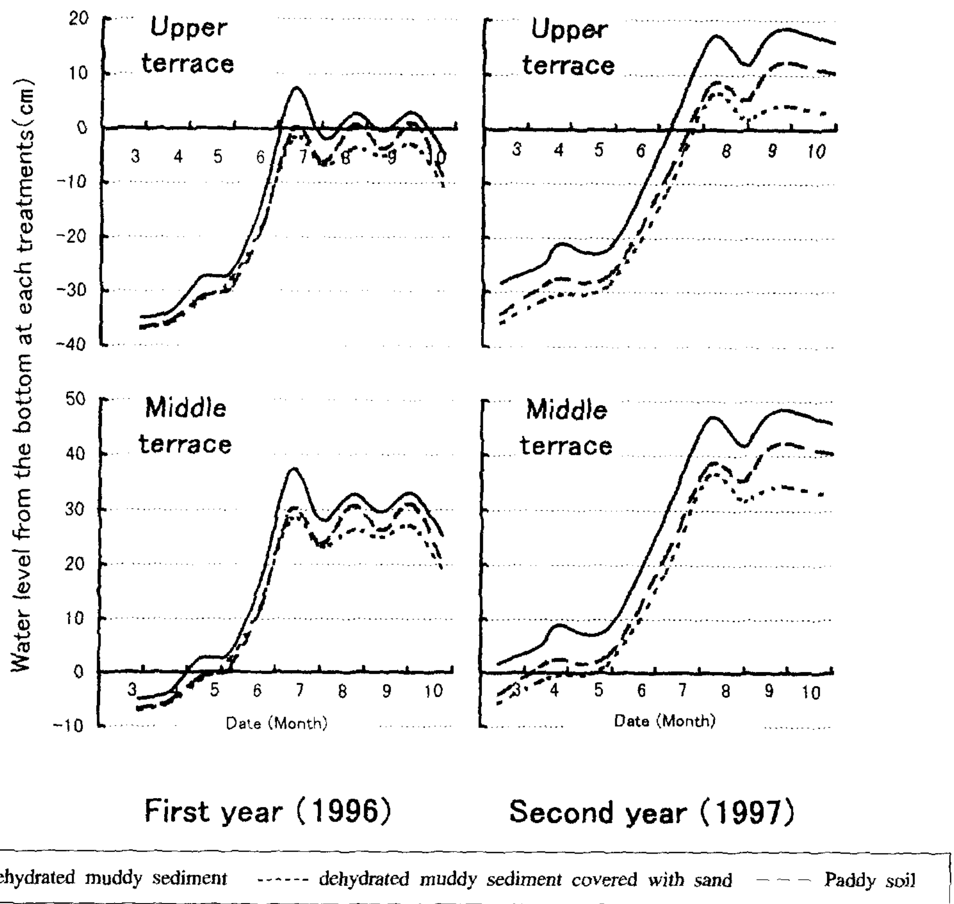

Fig. 4. Fluctuation in water level during investigation.[5]

physiological ability to withstand temporary environmental stress is necessary to promote them as a soil and water conservation tool.

Design and construction of vegetation bank :

Many bodies of water in Japan, especially in semi-closed water area, have become eutrophic as a result of the input of excessive plant nutrients from urban and agricultural activities. The input of excessive plant nutrients may occur together with an increase in soil effluent that accelerates sedimentation. Recently, as an operation to control the eutrophication, dredging for muddy sediment is extensively carried out. After dredging, however, the use of muddy sediment as useful resources has not developed sufficiently. Accordingly, the researches on utilization of muddy sediment as soil materials for vegetation bank been under trials in Kojima lake located in Okayama prefecture.

The shores on Kojima lake are often exposed by imposed fluctuating water levels in season as well as in a day (Fig. 4), Therefore we make some researches on effect of differences in water level under various soil texture conditions on growth of the selected weedy species. According to our research[5,9,10,11], *Schoenoplectus validas* and *Iris pseudacorus* are expected to be suitable plants on vegetation bank which made of the dehydrated muddy sediment, However there is still much left to be studied hereafter about the planting in the case of higher water level and the maintenance of plant community(Fig. 5, Fig. 6, Fig. 7, Fig 8)

CONTRIBUTION OF WEEDY TERRESTRIAL PLANTS

Soil erosion is a major environmental and agricultural problem worldwide, and also the problem

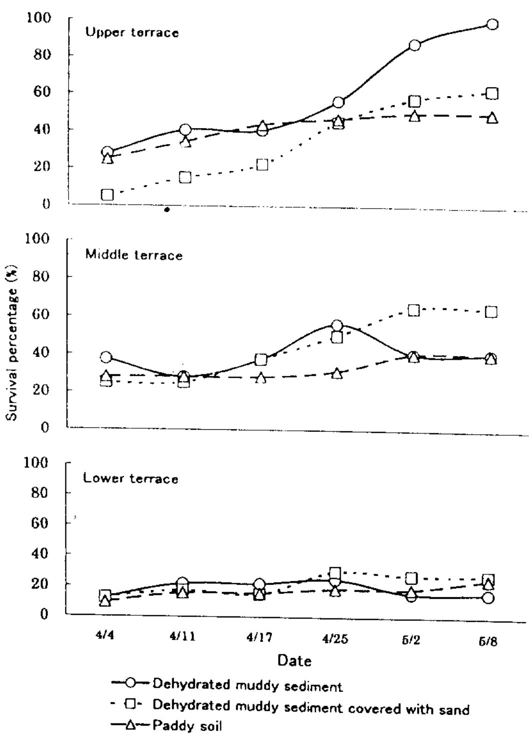

Fig. 5. Change with the passage of time in survival percentage of *Schoenoplectus validas* under different conditions.[11]

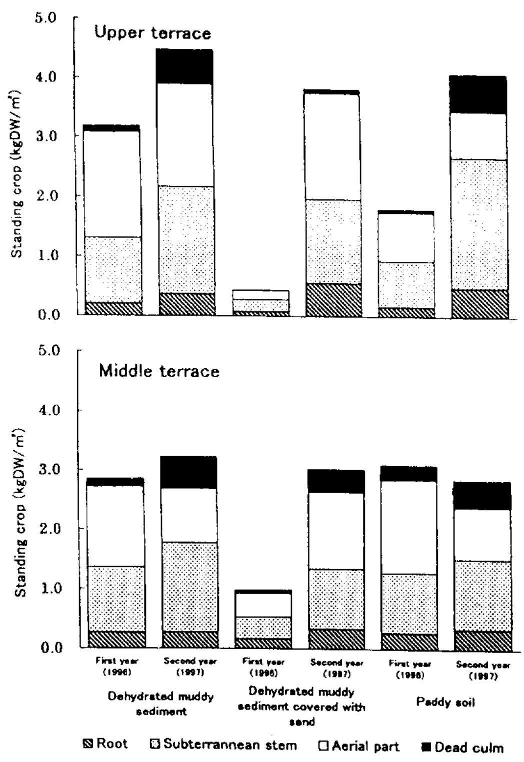

Fig. 6. Comparison of standing crop of *Schoenoplectus validas* populations for 2 years after transplanting.[11]

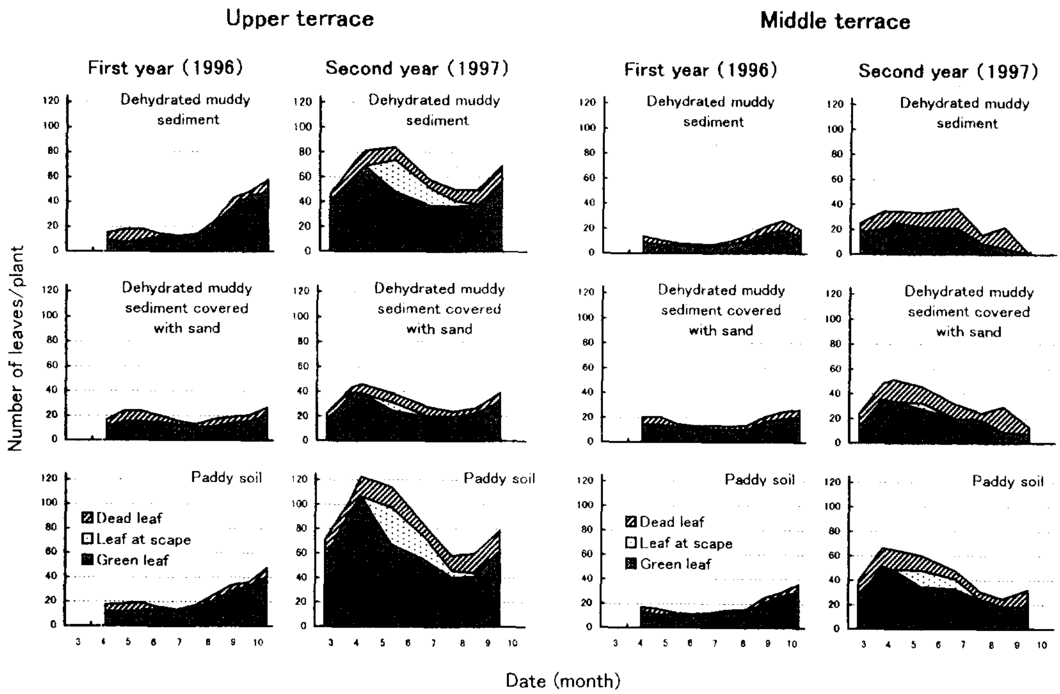

Fig. 7. Change with the passage of time in the number of leaves of *Iris pseudacorus*.[5)]

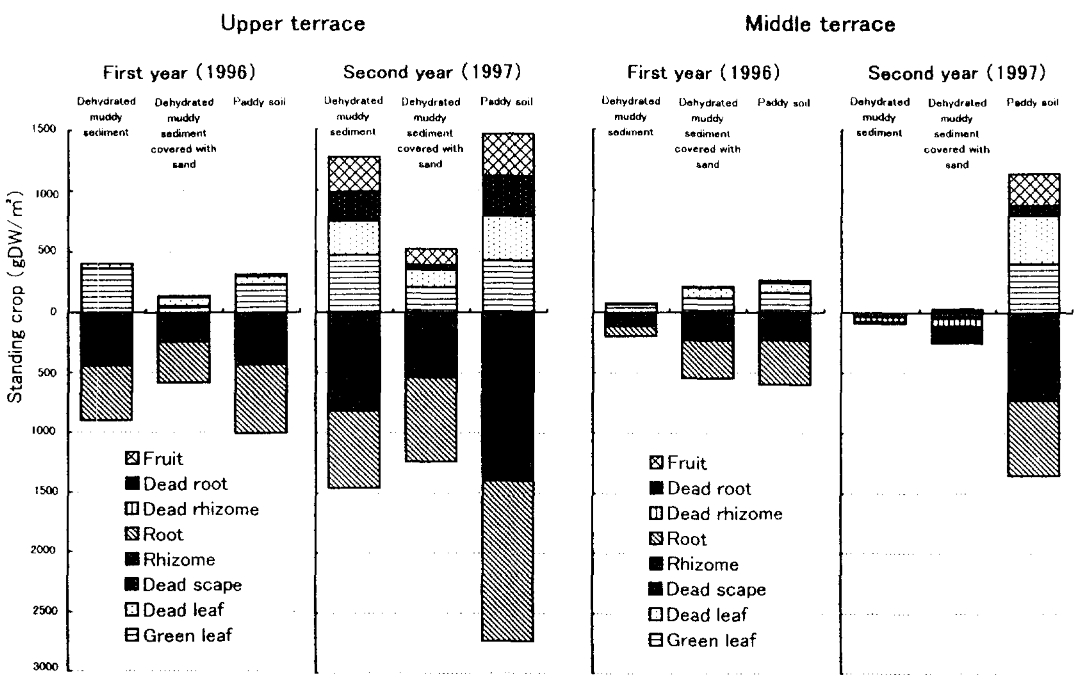

Fig. 8. Standing crop of *Iris pseudacorus* populations grown under different conditions.[5)]

of salinity is spreading all over the globe. About 10 million hectares of irrigated land are abandoned yearly as a consequence of the adverse effects of salinization and alkalization[19]. Although reliable soil conservation technologies have been examined, the conservation method by maintaining a protective vegetative cover over the soil reduce erosion rates.

There are many interactive processes between a plant and its soil that affect erosion. Some of these processes including the following : ① The physical binding of soil by plant stems and roots, ② Electrochemical and nutrient bonding between roots and soil, ③ Detention of runoff by stalks and organic litter, ④ Improved infiltration along root channels, ⑤ Greater incorporation of organic matter into the soil, resulting in better structural and water-holding qualities, ⑥ Increased faunal and biological activity, leading to better soil structure.

Therefore in resent years, we have conducted some researches on suitability of weedy plants as cover plants and their soil conservation abilities on slope area both in temperate and tropical regions, and also in the salt affected area.

<u>Interactive processes between vegetation and soil with erosion</u> :

The big project on the development of sustainable biological production technologies harmonized with regional environmental conditions in East Asia is proceeding from 1995, which is funded by the Grant-in-Aid Creative Basic Research from the Ministry of Education, Science, Sports and Culture. As a part of them, the research on interactive processes between vegetation and soil with erosion has been conducted on slope areas in Lampung, the South Sumatra, Indonesia[2]. The purpose of this research to examine how moisture regimes and soil erosion are affected by covering soil surface with weedy plants. We have selected the promising weedy plants, *Paspalum conjugatum*, as a cover plant from a viewpoint of erosion management, and set up the three treatments, namely which is keeping in weed-free, covered with *Paspalum conjugatum* and covered with natural vegetation, at the coffee plantation having a gradient of 16 degree. From a two year field investigation, we evaluate that *Paspalum conjugatum* has more effect on protecting against surface runoff. However their competing effect is becoming a serious problem lately, so that we must consider how to manage *Paspalum conjucatum* community

<u>Possibilities of vegetative cover with Cynodon dactylon in salt affected areas</u> :

Though *Cynodon dactylon* is most serious weed all over the world, they provide the important positive aspect such as a livestock feed or a cover plant which provide a very good protection to the soil, keeping it in its place with an ex- tremely intensive root system[14]. Also they prefer both habitats of the salt affected and the non-salt affected areas. Then the study on differences in salt tolerance within strains of *Cynodon dactylon* was carried out for using as a cover plant in the salt affected areas[13].

Nine strains of *Cynodon dactylon* grass were collected from various habitats such as the seaside, the saline soil areas and the roadside. These strains were grown in sand culture under greenhouse at various NaCl treatments, and their growth, morphological variation, mineral contents and rooting were determined. As a result, the growth of most strains was increased by Cl concentrations of 1,000 ppm to 3,000 ppm, and addition of NaCl up to 5,000 ppm of Cl concentrations did not affect their growth. Futhermore all strains survived relatively well even when grown with Cl concentrations of 10,000 ppm (Fig. 9). With increasing Cl concentrations, Na content in their tissues increased. Especially some strains which were collected from saline areas, had higher Na content in their tissues than those of other strains.

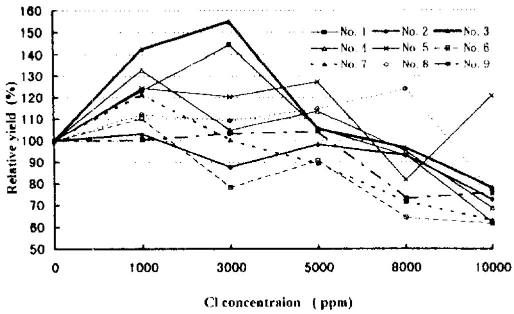

Fig. 9. Relative yield of 9 strains of *Cynodon dactylon* grown under various NaCl treatments.[13)]

It was also found that *Cynodon dactylon* may possess one mechanism for salt tolerance, which may be related to restriction of Na translocation from root to top (Table 2). Morphological characters of all strains at various NaCl treatment varied widely, and a relation between morphological variation and yield variation wad found. In contrast, NaCl treatments significantly affected the rooting and the root growth of *Cynodon dactylon.*

From these results, we estimate that *Cynodon dactylon* is useful in the salt affected areas because of the salt-tolerant plant.

CONCLUSION

Recently a new farming system that attempts to provide a balanced environment-sustainable agriculture has been encouraged. In order to contribute to water quality protection and environmental conservation in farming districts, the use of weedy plant for water purification combined with compost of mulch making will be a good idea. But the techniques for this should not be traditional ones but the ones which will produce a high value added. For example, when we use weedy plants for mulch, the effect will become more than physical shading if we choose those weedy plants which emit allelochemcals.

If we continue fundamental studies concerning the physiological and ecological characteristics of weedy plants, we will be able to find and utilize their high value-added functions. This will bring about new horizons not only to the field of environmental conservation but also to that of weed science.

Table 2. Na and K contents in the top and the roots of *Cynodon dactylon* under various NaCl treatment.[13)]

Strain[c)] No.	Cl concentration	Na(%)		K(%)		K/Na ratio		Na translocation rate to top(%)[b)]
		Top	Root	Top	Root	Top	Root	
5	0 ppm	0.18	0.39	1.68	1.07	9.20	2.72	31.69
	1000ppm	0.21	0.59	1.56	1.06	7.25	1.81	26.78
	3000ppm	0.32	0.73	1.53	0.96	4.71	1.33	30.91
	5000ppm	0.35	0.88	1.39	1.01	3.96	1.14*[a)]	28.58
	8000ppm	0.47*	0.98*	1.49	0.84	3.18	0.86*	32.40
	10000ppm	0.54*	1.06*	1.50	0.84	2.80*	0.79*	33.63
7	0 ppm	0.11	0.24	1.43	1.12	12.58	4.62	34.33
	1000ppm	0.14	0.45	1.34	1.09	9.59	2.42	24.46
	3000ppm	0.25	0.57	1.39	0.91	5.51	1.58	30.37
	5000ppm	0.33	0.60	1.29	1.01	3.91	1.68	36.94
	8000ppm	0.40*	0.79	1.38	0.91	3.42*	1.15	33.72
	10000ppm	0.47*	1.09*	1.31	1.00	2.81*	0.92	30.15

a) * Significant difference at 5% level
b) Na contents in top / Na contents in whole plant × 100
c) No. 5 : Collection from saline areas, No. 7 : Collection from non-saline areas.

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