招 請 講 演
Invited Lecture

A Looking－over of Weeds
－BASED ON SOME EXAMPLES IN JAPAN－

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Introduction

The questionaries on a view of weed science toward 21 century, filled out by members, in the 25 th anniversary of the foundation of Japan Weed Science Society, in 1986, tells us that the important things to promote weed science in future are firstly, to forecast the weeds germination and to diagnose ill effects by weeds, and secondly, to develop new herbicides and biological weed control. It is necessary to develop the weed science to yield crops, to improve environment of the cultivation, and to maintain their environment because we should control, make useful, and live together weeds. On account of them, we must attach great importance[22] to the basic study about weeds physioilogically, ecologically, and biochemically.

Though weed of great worth is not discover too much, its veil of mystery is stripped gradually with the development of modern science. Today, an over looking of weeds is the important subject for a future.

I consider some chief matters about an over－looking of weeds in Japan here for a new epoch.

Weeds classification in C3 and C4－plant and habitats

Recently, it was found each plants have a lot of different assimilates, which are basic action of plants. That is to say that widely photosynthetic action has two reaction lines, light reaction (photochemical reaction line) and dark reaction (CO_2 fixed reaction line). Dark reaction is classified photosynthesis line by Calvin－Benson cycle (C_3 type of photosynthesis line), well known, and photosynthesis line by Dicarboxylic acid cycle (C_4 type of photosynthesis line), whcih was discovered lately. We call the former C_3 plant, and the latter C_4 plant. Dark reaction has known with CAM type besides these, and we call it CAM plant.

Most plants are classified these three types, C3 plant, C4 plant, and CAM plant, and each of them has different characteristics, especially, in leaf tissue, photosynthetic rate, CO_2 compensation point, photorespiration, and water requirement. These interest in many kind of fields, and are examined in weeds and weed control.[23] It gets much attention especially about the distribution and the competititon between C3 plant and C4 plant.

We[12] investigated the relation between the distribution and the habiat of weeds, C3 plant and C4 plant, in paddy field, farm, and orchard, beeing in the same area. Consequently, many C3 plants and some C4 plants, which are adapted to wet land, apt to germinate in irrigated paddy field. Many C4 plants are dominant weeds in a asparagus field because of the high photosynthetic capacity, come from the comparatively strong sunlight and the dryness, of the high growth rate, and of the low water requirement. Small-sized C3 plants are dominant in a vineyard. To my thinking, the creeping and perennial C3 plants are dominant species because they are fit to the environmental condition in a vineyard, for example, gentle

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sunlight and enough soil moisture content by the trellis training, and weed cutting.

Many crops belong to C3 plant, while most of strong harmful weeds are C4 plant. That is to say that C4 plant has high photosynthetic capacity under the conditions, high temperature and sunlight, and can make good use of water. The relation between C3 and C4 plant must be examined deeply to understand the competition between weeds and crops.

Weed control and intraspecific variation

Most plants are controled severely by the environment in the inhabitting "place", because they cannot move to another place. Plants, however, have a keen "sense"to read the changes of the environment precisely, and so they are able to survive in the environment.

The environmental conditions have changed again and again through the long historty on the earth. Plants, especially each weeds have grown their multiformities to adjust themselves to the hard changes.

The intraspecific variation is one of the multiformities. It is said that the most conspicuous intraspecific variation of plants is the differentiation of ecotype, so I am going to state about the various weed controls and the intraspecific variations.

Alopecurus aequalis SOBOL., for example, is classified two ecotypes, the paddy field type and the farm type, and it is reported this is genetic differentiation.[10] The paddy field type, commonly in good environmental conditions, has large seeds, always makes preparation to germinate if the oxygen pressure becomes high, and its photoperiodic response is neutral. Thus, *Alopecurus aequalis* is at the top of weeds in paddy field in off−season because it has better conditions to make the community than any other weed. While the field type, which environmental conditions are usually unstable, has the automatic dormancy in seeds, so it has double or triple safety valves against narrow adaptable bounds of the environments and song day conditions, which are physiological and ecological safety valves in short, and providing the genetic variations by outcrossing to adjust oneself to the unstable environmental conditions in fields. It is worthy of notice that this weed is established very well in the environmental conditions, both in the paddy field and in the farm, which have different weed controls.

Then I investigated *Eleocharis kuroguwai* OHWI, which is perennial weed and to control is hard, about the styles of adaptability in the habitat by researching the variations of photoperiodic response in the tuberization. Consequently,[3] the growth period of *Eleocharis Ruroguwai* is the same as that of paddy rice. This weed is classified the paddy field type, having much water excepcért in the dry −season and periodical weeding control, and the pond type, which banks are drying in mid-August on account of supplying field with water, and do not have enough control. The genetic differences are found between the clones in the paddy field and the pond to adjust each habitats well. It is possible to reconsider how to control the strong weeds and the cultural system of plants, by understanding the styles of adaptability of *Eleocharis Ruroguwai* in the paddy field and the pond.

It is found that *Poa annual* L. shows several variations against each characteristic in the places in a golf links.[2] There are many kinds of places to play in a golf course, and each of them has different weed controls ; for example, the length of plants in tee are kept about 10 mm, 20~30mm in fairway, 35~50 mm in rough, and 5 mm in green during the golf season. Thus, this weed grows in these very particular habitats, so this has some variations in each places, green, tee, fairway, and rough, to adjust its length, heading date, and seed production to each weed control. The relative premature birth and small-sized variations in these grow in a part of green and tee, trimming to very short and high pressure by stepping. This is a very important fundamental data about the adaptiability to the environments and the ways of ecological control of weeds.

Allelopathy between weeds and crops

Since MOLISCH(1934) studied allelopathy for the first time, it was examined in many kinds of fields as time goes on, and now, is the general study from higher plants to microorganisms. Nowadays, allelopathy is considered as not only herbology but also "chemical ecology", the new field of ecology, and some books have been published, for instance, "Allelopathy"[15] by Rice(1974), "The Science of Allelopathy"[14] by Putnam and his colleagues, and so on. These will contribute really for the development of this field in future.

Galium spurium L. var. *echinospermon*(WALLR.) HAYEK, for example, is a troublesome weed in a wheat field and an orchard, but has germination inhibitor in the immersion water of seeds. The experiments, making pure by column chromatography and a thin layer chromatography, and identification by UV, IR, HNMR, and 13-NMR, found that this germination inhibitor is monoterpene lactone glucoside called asperuloside, the molecular formula is $C_{18} \cdot H_{22} \cdot O_{11} \cdot H_2O$.

These chemicals inhibit seed germination and seedling growth in lettuce and alfalfa remarkably. These are dissolvable in water easily, so they may move from seeds to the soil and allelopathic effects appear. They can inhibit plants, especially the length of radicles[6] still under phytohormone, GA_3, Kinetin, IAA, and so on.

Next, it seems that *Cyperus rotundus* L. is regarded as one of the most harmful weeds in the world becaue of the variation of their physiological and ecological characteristics : they can easily adapt themselves in various types of environment.

Purple nutsedge also contain several essential oil compunds accumulated in tubers which mainly consist of sesquiterpene such as α-cyperone, β-selinene, Cyperene, Cyperenore. It has been found that there is some geographical continuous variation in its composition.[8] This seems to be important for control of them because this characteristic can make possible the researches on intraspecific variation.

As a result of experiment, it was found that 100 ppm~200ppm of the essential oil inhibited the growth of white clover, *Digitaria cyliaris*, *Rumex obtusifolius* L., and lettuce. Much of these essential oil compunds are contained in tubers, substerranean stems and roots ; they have also been detected in the soil where Purple nutsedge grow. These facts indicate that they have an allelopathic action against other plants' germination, growth and micro-organisms in the soil.

It is noteworthy that these compounds also have strong inhibitory action to tuber germination and growth of Purple nutsedge itself in which they are contained : it is considered that they have an effect on the physiology of the germination, development, furthermore, the succession and decline of Purple mutsedge vegetation.[9]

Perilla frutescens var. japonica(Perilla frutescens family) is known to inhibit the growth of other plants. The essential oil seperated from this plant, which is contained most in leaf, has its peculiar odor. The essential oil compound has been also detected in the soil where *Perilla frutescens* is grown. As a result of experiment, it was found that 10 ppm of this compound interfered the growth of young plants of lettuce and *Digitaria cyliaris* ; 500 ppm of it killed them. *Digitaria cyliaris* was more affected than lettuce.

This inhibitive substance has been found to be perilla ketone classified among mono—terpene ketone, which is noticed to have strong inhibitive effects against a few microorganisms.[7]

These allelopathic actions stated above will be very significant as new control methods of weeds if they are used for development of new natural herbicides and introduction of resistance to weeds into crop plants.

Appearance of resistant weeds to herbicide

In recent years, moıe attention has been focused on several problems-that is, intraspecific variation of weeds to the ones susceptible to herbicides, dominance of perennial weeds brought about by the application of various herbicides, and appearance of resistant weeds to herbicide, which is to be described from now. As a result, not only weeds' selection of herbicide but also the difference of susceptibility between the plants of the same family need to be considered and discussed for better weed control.[20]

Now in Japan, long application of a same herbicide has been observed to largely affect the composition of a weed community ; this results in dominance of resistant weeds to the herbicide, simplification of the weed varieties. A few examples are to be described.

First, skevish(*Erigeron philadelphicus* L.) has been become resistant to paraquat as a result of its application for seven~ten years.[21] In mulberry fields experiments showed that 16kg/ha paraquat did not kill the resistant *Erigeron philadelphicus* L. completely. On the other hand, all *Erigeron philadelphicus* L. collected for comparison in the place where paraquat had never been applied were almost completely killed by 0.5 kg/ha of paraquat.

Secondly, it was found that no *Erigeron canadensis* L. was killed by the standard application amounts of paraquat and diquat when they were applied two or three times a year from 1968−1969 to 1981.[1] According to experiments, the resistance of *Erigeron canadensis* L. was found to be almost 100 times as strong as the one of the plant grown in the place where they had never been applied.

Poa annua L. has some variation types adapted to some parts of a golf course, in which weeds are controlled differently as described before ; green is controlled exclusively by pulling applied for weed control. As a result, the weeds in fairway and rough were found to have extremely strong resistance against simazine. According to these facts, it was made clear that the known adapted variation types also had both resistant and susceptible individuals against herbicide.[4]

Considered the appearance of resistant weeds against a herbicides stated above, it is needed to make clear the mechanism of the resistance of weeds for new weed control ; at the same time, indiscreet introduction of herbicides should not be repeated.

Characteristics and utilization of weeds

It is nonsense to 'regard weeds as a nuisance' ; for new weed control, it should be rather emphasized to utilize the tenacious vitality of weeds, reconsider the advantages and put a lot of unknown characteristics of them to practical use ; that is, the control of them by their utilization. So it is important to utilize weeds actively. For example, they could be useful if they are used as a new type of bio−mass with which the energy of the sun is fixed.[17]

In 1919, a famous botanist in Japan, Tomitaro Makino published a book "Studies on Weeds and Utilization", in which he stressed the importance of the use of nature. This is still his warning to people of today after a period of 70 years. I am going to state a few examples of the utility of weeds.

Eichhornia crassipes(MART.)SOLMS is regarded as one of the most difficult hydrophytic weeds to control[18] in the world ; it is because they grow abnormally in number due to changes in surroundings, especially eutrophication of water, and a rise in water temperature. For this characteristic, they could be useful if they are used for sewage purification, making forage, manure, and bio−mass.

Waterhyacinth has a great propagation power as stated above. Another significant characteristic is its facility of incorporation of solor energy, compared with other biomass materials such as giant kelp(*Macrocystis* spp.)of which facility to incorporate solar energy is remarked in the United States.[5] This means that it is easy for them to get much more sunlight to the surface of a leaf ; consequently carbon dioxide and carbon are supplied to leaves at a rapid rate, nutrient salts as N or P are efficiently absorbed by them. In additon, there are still some advantages ; for example, it contains more Lys and Cys ; it also contains no restriction amino acid compared with giant kelp.

Therefore, to put these advantages in it to practical use, the utilization of it as forage, silage, manure, and amendment, and the production of bio−gas which mainly consists of methane are tentatively being conducted. As waterhyacinth has also been reported to absorb to a great extent a heavy metal,[16] it is now being researched for purification of sewage, and collection of metals.

In putting waterhyacinth to practical use, it is necessary to keep in mind the synthetic utility system of natural circulation ; that is, waste water as a reslt of living and animal husbandary is led to the breeding place of waterhyacinth, and the water purified there is discharged into rivers ; the propagated plants can be used as forage, manure, and they can be also used for the production of methane.[13]

In Japan, a lot of researches are now being carried out for better control and utilization of hydrophytic weeds such as waterhyacinth. As part of them, the Waterhyacinth Society of Japan was associated ; moreover, the book "Mizukusa no Kagaku"[19] I compiled was also published.

Measures against weeds in the future

Considering various problems and situations about weeds in agriculture of these days, I stated the measures against them in the future. I think the facts show that the problems about weeds will never be solved if only the harm on crop plants, which aim at increase in production, is technically eliminated.

For new weed control, it is necessary to overlook and understand weeds again : the morphology, the physiological ecology of every kind of weed, characteristics of weed community and the changes of it. Subsequently there must be some new recognition of harm caused by weeds.

Based on these factors, overall system of weed control which includes mechanical, chemical and biological control is expected for the coming decades. It is also necessary to study the measures against weeds for coming new age−in other words, as described before, the way of controlling weeds which includes prevention of weeds by utilizing them for our life.

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