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Invasion and control of water hyacinth (*Eichhornia crassipes*) in China*

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Abstract: By the time of primary 21st century, water hyacinth had become a serious environmental problem in China. Water hyacinth contributes to the major part of ecological hazards from the invasion of foreign plant species, which is estimated about USD 7 billion a year in values.

In the past 10 years, herbicides glyphosate, 2,4-D and paraquat have been used in controlling water hyacinth in China. Although the herbicides provided effective control on the weed in some areas, they could not provide the sustainable inhibition on the weed population, while would lead to pollution on water at various levels. At present, the herbicide application on water hyacinth is forbidden in many areas of China such as Shanghai. In this situation, the asexual reproduction inhibitor, KWH02, was invented for controlling water hyacinth and it provided about 70% of growth inhibition without any risk of dead plant pollution.

It has been about 10 years for bio-control of water hyacinth in China. Works focused on mainly the efficacy and safety of the utilization of foreign insects. Researches on microorganism herbicides to control water hyacinth were started and obtained primary achievements in recent years.

Although there are different opinions on how to face the water hyacinth problem in China, it is accepted widely that the control methods should be high efficient and safe with low cost. Some practical measures for integrated management of water hyacinth are suggested.

Key words: Invasion, Control, Water hyacinth, China
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INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) was first introduced from South America into China as a good fodder plant in 1901, and had become a serious environmental problem in China by the early 21st century (Ding *et al*., 2001). Of the total loss of USD 7 billion brought about by foreign weed species in China, water hyacinth occupies the major proportion. The large coverage of this weed on water would reduce sunlight penetration and lower oxygen content in water, which has a great impact on water eco-system, thus the local species would be decreased. For example, 60% local species living in Dianchi Lake in Yunnan Province was died out by the invasion of water hyacinth. The output of fishes and other water foods would be reduced in a large scope. Many water areas would be difficult to ship and many canals would have problems for irrigation and drainage. In addition, the presence of water hyacinth would be negative for sightseeing. In 18 provinces or cities infected by water hyacinth, Shanghai is a typical area. Only in 2002, water hyacinth of 1.68 million tons was salvaged in Huangpujiang River and other water areas in Shanghai and more than USD 10 million was spent in a year. From 2002 to now, and Shanghai government has invested more than USD 1.2 million on the project of integrated management on water hyacinth. Some important results were obtained and in use. This paper focused on our research results and the integrated management strategy on water hyacinth in China.

Herbicides have long been used to control water hyacinth (Terry, 1991). In the past 10 years, herbicide glyphosate, 2,4-D and paraquat have been used in

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controlling water hyacinth in China. Although the herbicides effectively reduced weed infestation, they do not provide a long-term sustainable control, and pose problems of polluting water. In addition, weed mass killed by the herbicides may also decrease oxygen in water and cause a secondary pollution harmful to fish. It is for this reason that in many areas of China such as Shanghai, we decided to test a chemical inhibitor of the asexual reproduction of water hyacinth, such as KWH02, which has been developed and applied for an patent (Chu, 2004a).

KWH02—AN INHIBITOR FORMULATION TO CONTROL ASEXUAL REPRODUCTION OF WATER HYACINTH

Materials and methods

1. KWH02 effect on individual branches of water hyacinth

The experiments included six treatments and control tested in concrete pools (50 cm×50 cm×50 cm volume). Each pool contained only one weed individual. The treatments were as follows: treament 1 (T1)—KWH02 at the rate of 1.5 kg/ha, treatments 2 to 6 (T2~T6) are single chemicals or other formulations at the same rate dosage comparatively with KWH02. The data was collected every day in 29 d after spraying.

2. KWH02 effect on total branches of water hyacinth in the growth pool

The experiments included six treatments and control also, and the methods were the same as above. But each pool contained a mass of water hyacinth with 250 g fresh weight.

Results

In the experiments of individual weed, water hyacinth showed to have a strong ability to produce branches. The control, water hyacinth without treatment, produced more than six branches. Treatments 1 to 6 (T1~T6) inhibited the reproduction of water hyacinth at various levels, and KWH02 could provide the highest inhibition (70%) on individual branching compared to the control (Fig.1).

In the experiments of total branches, normally a plant of water hyacinth produces an average of four new shoots branches every 26 d, while the plant treated with KWH02 at 1.5 kg/ha (Fig.2) produces only an average of 1.3 shoots. Such a treatment provides 72% control of weed after the application. Similar results were obtained with further experiments conducted later in rivers and lakes.

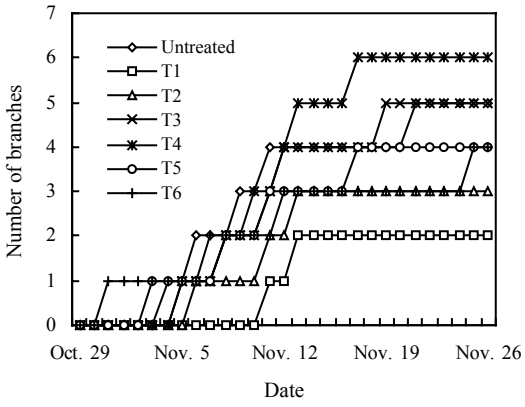

Fig.1 Effect of KWH02 on number of shoots of water hyacinth in the growth pool

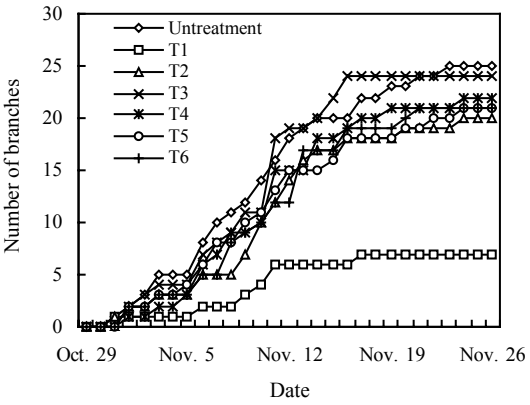

Fig.2 Effect of KWH02 on the total number of branches of water hyacinth

Toxicity concern of KWH02

The formulation of KWH02 was tested according to China GB15670-1995 (test method on toxicity for pesticide registration). The report of the toxicological studies conducted by Jiangsu Provincial Sanitary and Anti-Epidemic Station revealed that the oral LD_{50} of the male and female rats were higher than 5000 mg/kg body weight. Such a result makes clear that this compound belongs to the category of low toxicity herbicides, while the acute dermal irritation test and the integral index of the acute eye irritation test on rabbit showed no negative effects at all.

Evaluation of KWH02

The use of such an inhibitor is a new approach for the control of water hyacinth population without killing the plant. The active ingredient of KWH02 formulation have the advantages of being low toxic, decomposed fast, and do not pose any risk of pollution to the environment. In addition, it is also of low cast. Its water-soluble powder formulation, in particular, has a content of natural substances above 90%, and it also includes an adjuvant of plant origin, which has also been successfully used in a water-soluble powder formulation of glyphosate during the last 10 years. Thus, the use of KWH02 has started recently for the integrated management practice of water hyacinth in Shanghai water bodies, and it gained immediate success.

BIO-CONTROL OF WATER HYACINTH IN CHINA

The studies on biological control of water hyacinth started 10 years ago in China. Most of this work has been focused on the effect and safety of the utilization of specific exotic insects. It was not until recent that research has been initiated on microorganisms as potential herbicides for the control of water hyacinth.

In 1995, the weevils *Neochetina eichhorniae* and *N. bruchi* were introduced separately in China from USA and Argentina (Ding *et al*., 2001). In order to evaluate the safety of weevils, 46 different plant species of economical importance were selected, including also ornamentals and some wild aquatic plants in Dianchi Lake, Yunnan Province for studies of host specificity. As a result none of the 46 species were found to be edible by *N. eichhorniae* (Liu *et al*., 1997). Similar results were obtained with the subsequent experiments conducted in various provinces, which clearly indicate that the weevils are safe to be used for the control of water hyacinth in China.

The effects of weevil on water hyacinth control varied from one place to another. Four sites in Wenzhou City of Zhejiang Province were selected for the experiments by CAAS (China Academe of Agricultural Science) in 1996. A release of 1000 insects/(1000 m^2) in two sites exerted an efficacy around 90% of the water hyacinth infestation for the next three years after this release, while no weed control was observed and no weevils were found in the other two sites (Ding *et al*., 2001).

Research on the use of microorganisms to control water hyacinth began in 2000 in China. In 2003, Shanghai Jiao Tong University received the financial support from Shanghai government to develop and test a myco-herbicide formulation for the control of water hyacinth. At present, nine fungal species have been isolated from water hyacinth of Shanghai and Zhejiang Province, which showed various effects on the growth of water hyacinth in laboratory test. In order to improve the quality of myco-herbicide formulation, particularly when it is sprayed in the field, a non-ionic tenso-active surfactant extracted from wild camellia was included. This adjuvant should improve weed control by keeping the leaves of weed wet for even more than 5 d, a sufficient period for the fungal mycelium to infect the weed tissue.

DISCUSSION

In the vast territory of China there are huge differences in the environmental conditions among various provinces. Thus, the practical strategy on integrated management of water hyacinth should be chosen according to the local condition including the climate, level of water pollution, and local affordability.

In South Eastern China, leaves of water hyacinth would perish in winter, while the plant will stop its growth. However, central buds of the weed are active and would produce new shoots in the coming summer. In this case, saving the perished frond in winter would be an efficient method to reduce the weed stand in the next year. It would be an excellent preventive measure to control water hyacinth at low cost. In places of Southern China, such as Fujian, Guangdong and Yunnan provinces, water hyacinth grows throughout the year, and exotic weevils and/or local insects could be released and used for controlling the weed.

Chemical herbicides could be used in limited areas, where water is not used for drinking and the weed stand is high. The asexual reproduction inhibitor, KWH02, is a suitable control agent in areas, where water is used for drinking and also in lakes, pools, and creeks, where water flow rate is slow. In

rivers, however, it is necessary to block the abundant flowing populations of water hyacinth, although it may imply the use of large labour and materials use at high cost. In the case of plenty water hyacinth saved from water, it is very important to treat the weed in time in order to avoid second pollution to the environment caused by the dead and decay of the weed. We can use water hyacinth to produce organic fertilizer (Chu, 2004b).

In long term, water hyacinth management should be implemented taking into consideration the whole eco-system. There is a need to reduce sewage from industry and man activity, to regulate the pollution caused by inputs used in the agricultural, to take effective measures to keep the natural balance of the eco-system, to solve the present contradiction between economical development and environmental protection, and to introduce new successful foreign technologies in China that may save resources used for research and control. These all are urgent questions, which need to be responded in China.

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