AU J.T. 15(2): 77-82 (Oct. 2011)

Giant Salvinia – An Invasive Alien Aquatic Plant in Thailand [1/]

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Abstract

Giant salvinia (Salvinia molesta) *is an introduced floating aquatic fern native to Brazil. It can reproduce vegetatively and under ideal growing conditions can double its biomass every 3-5 days. It can form mass on the water body, blocks out the sun's rays from penetrating through, thereby inhibiting photosynthesis of submerged aquatic plants. Water quality is impaired under these masses, especially in areas with restricted water movement. Although the Act banning its introduction and cultivation has been promulgated since 1978, there is still a problem in controlling its distribution as well as in eradicating it. At present, however, only two areas, in which giant salvinia creates some problems, are in restricted areas in the Central and Southern parts of the Thailand. Luckily, the local administrative officers were effective in controlling its widespread distribution through people's participation program in eradicating the giant salvinia. Chemical control is by the use of paraquat herbicide, but not officially recommended, except for use directly on the plant, or in turbid water. Although not at present troublesome for the waterways, awareness through surveillance should be done by notifying the public to be aware of its danger and not cultivating it.*

Keywords: *Plant introduction, noxious aquatic weed, rapid multiplication, impaired water quality, herbicide spray.*

1. Introduction

It is well known that plant introduction plays a key role in development. In an agricultural country like Thailand, plant introduction has contributed significantly to agricultural development. Numerous varieties of many species of cultivated plants have been widely accepted by the growers. Many have made Thailand the world's largest exporter of commodities derived from such introduced plants, e.g. cassava *(Manihot esculenta),* pineapple *(Ananas comosus)* and para rubber *(Hevea brasiliensis)* introduced from South America.

Introduced ornamental plants have also enriched Thai growers with their numerous species and varieties. Orchids introduced from various lands, after hybridization and selection, have made Thailand the world's largest exporter of orchid cut flowers.

An endless list of plant species and varieties can be made to show that such introduced plants have made significant economic progress of Thai agriculture such that Thailand becomes one of the few countries that feed the world, not only of foods, but various other commodities such as ornamentals as well as cosmetic, pharmaceutical and industrial products.

The negative side of plant introduction is its role in dealing with noxious weeds which have created a lot of problems in their eradication, most of which are nowhere close to complete winning the war in fighting with these alien invasive plants.

[1/] Paper presented at the 62nd Spring Meeting of the International Association of Horticultural Producers (AIPH), Suncheon, Korea, 4-6 October 2010.

2. Noxious Invasive Alien Plants in Thailand in the Past

2.1 Water Hyacinth *(Eichhornia crassipes)*

A native of South America, water hyacinth with its beautiful light blue flowers resembling hyacinth - thus the name water hyacinth, was introduced from Kew Botanic Gardens to be grown in Bogor Botanical Gardens in Indonesia where it was later introduced into Thailand in 1900. As it escaped cultivation into the waterways and spread rapidly as it could double its biomass in 5 days, an Act was passed in 1904 to ban its cultivation, but until now the war between man and water hyacinth is still going on, not only in Thailand, but in more than 50 tropical and subtropical countries around the world.

2.2 Burmese Grass *(Pennesetum pedicellatum)*

It was introduced from Tropical Africa as a forage crop in 1955**,** but later found out to be invasive as it reproduces and grows very fast. Although it can be used to make pulp and paper, its widespread occurrence created a big problem for field crop farmers as the seeds could be blown far away by the wind and once landed, readily germinate and occupy the farmer's fields such that it is difficult to get rid of it.

2.3 African Giant Mimosa *(Mimosa pigra)*

It was introduced from Central America as a covering plant for deserted infertile land with the hope that it can be used to improve soil fertility due to its nitrogen fixing ability, after its relative, *Mimosa invisa,* has been found to enrich the soil and can be used as a forage crop. It later turned out to be such a noxious invasive plant that its complete eradication is impossible.

3. Salvinia – An Aquatic Fern

It is still a surprise to many people to know that there exist aquatic ferns. Although there are many groups of aquatic ferns, salvinia, commonly known as the floating water moss, is the most popular since it is quite beautiful, and as such, used as ornamental plant in ponds and water gardens as well as in the aquariums.

Salvinia is a free floating aquatic plant that is not prone to disease and decay. It is an annual plant that floats on the water surface due to the amount of air in the plant's tissue. This bit of excess air makes the fern look spongy in appearance. It is an interesting and easy to grow plant for a water garden and helps to purify waste or contaminated waters because it could remove organic material from eutrophicated water. Floating salvinia can be a wonderful addition to a water garden or pond that has fish or other living creatures due to its purification capability. It consists of horizontal stems that float just below the water surface, and produce, at each node, a pair of floating or emergent leaves which are green in color and ovate to oblong in shape. Plants bear a third leaf that is brown.

It belongs to the plant family Salviniaceae. The sole genus, *Salvinia*, to which it belongs, consists of about 12 species. There are many differences between the species of *Salvinia.*

- *S. cucullata*, a triploid species, has been found in Thailand for a long time with not much impact on the environment. It is an annual plant that can be found in ponds and waterways. Its mature leaves are quite different from other species. Its stems are covered with single hairs. Uppermost leaves are entire at the apex, to 1.2 cm long, broader than long with margins curving upwards and inwards; upper leaf surfaces with papillae in irregularly curved rows, the tips not joined. Short and dense sporocarps are formed on the submerged, root-like lower leaves.
- *S. natans*, or water moss, is used as a free floating ornamental plant for aquariums and ponds, features for its decorative nature without invasive characteristics.
- *S. auriculata,* is a complex species which includes several other species including *S. molesta*, or the giant salvinia. *S. molesta* can be an invasive weed that runs rampant in the warmer areas of the world. It is also known in many localities as African payal, Kariba weed,

and salvinia water fern. The characters of *S. molesta* are leaves longer than broad with deeply indented leaf apices; the papillae hairs are joined at their tips to form a cage-like structure (Waterhouse & Mitchell 1998).

4. The Characteristics of The Giant Salvinia

4.1 General Characters

A pentaploid species, giant salvinia is a free floating aquatic plant that does not attach to the soil. It has no true root system. It thrives in slow-moving, nutrient-rich, warm freshwater. A rapidly growing competitive plant, it is dispersed long distances within a water body (via water currents) and between water bodies (via animals and contaminated equipment, boats or vehicles). Used as ornamental plant, it is grown in aquariums and ponds where it is sometimes released by flooding, or by intentional dumping. It may form dense vegetation mass that reduces water flow and lowers the light and oxygen levels in the water. This stagnant dark environment negatively affects the biodiversity and abundance of freshwater species, including fish and submerged aquatic plants. It can alter wetland ecosystems and cause the loss of biodiversity. It also poses a severe threat to socio-economic activities dependent on open, flowing and/or high quality water bodies, including hydro-electricity generation, fishing and boat transport.

4.2 Description

Salvinia molesta produces a horizontal branch, known as 'rhizome', that lies just below the water surface. It has two types of leaf, known as 'frond', floating and submerged. The mature plant produces egg-shaped spore sacs containing infertile spores (due to being pentaploid with 5 sets of chromosomes). Its fronds are in whorls of three - two floating and one submerged. The two floating fronds are borne opposite to each other, round to oblong in shape, and having several rows of cylindrical papillae on the upper surface. Each papilla has four hairs at its distal end. Each hair consists of a single row of cells that are joined together at their tips to form what looks like an inverted egg-beater. The cage-like structure of the hair tip is an effective air trap giving the plant buoyancy. The upper surface of the frond having papillae and hairs is water repellent in comparison to the under surface, which attracts water. It is this difference in water attraction that maintains the correct orientation of the plant on the water surface. The fronds are light to medium green, often with brownish edges in mature plants, and with a distinctive fold in the center. The submerged fronds function as roots. The plant exhibits great morphological variation depending on the conditions of habitat, such as space and nutrient availability, and ranges from a slender floating specimen with leaves less than 1.5 cm wide to one with leaves up to 6 cm wide

5. Beauty Turns into Beast

5.1 Legislative Act

In 1978, the author participated in the Southeast Asian Symposium on Aquatic Weeds in Karang Kates, East Java, Indonesia. During the study tour to observe the widespread of aquatic weeds in Karang Kates Reservoir and the adjoining rice fields, he saw the luxuriant growth of the giant salvinia and observed its mode of distribution. He also discussed the danger of this aquatic fern with Dr. D.S. Mitchell, the world expert on *Salvinia molesta.* Dr. Mitchell suggested to him that Thailand should have a strict control measure not allowing the importation of the giant salvinia. The author reported to the Aquatic Weed Coordinating Committee of the National Research Council of Thailand, which he chaired, concerning the danger of the giant salvinia. The Committee unanimously agreed to notify the Ministry of Agriculture and Cooperatives to promulgate the Act on the prohibition of importing giant salvinia into the Kingdom as well as in cultivating it. The Act, No. 14, was promulgated on 15 December 1978.

5.2 Previous Attempts to Control the Widespread of Giant Salvinia

With the Act on "the Inhibition of Importing Giant Salvinia into the Kingdom" in force, Thailand has been freed from this invasive aquatic fern for 23 years. In 2001, however, giant salvinia was found in the stands of medicinal plants in the famous Chatuchak Weekend Market in Bangkok. An officer of the Department of Agriculture notified the sellers that this was illegal and demanded that the specimens were removed and destroyed.

In 2007, the Weed Research Group of the Department of Agriculture (DOA) obtained a grant to do research on surveillance of the giant salvinia in Thailand for a period of one year. The result indicated that there were 12 shops selling giant salvinia and 10 people grew it as an ornamental plant. There was also a study on its growth habit in cement ponds and found that it grew very fast, increasing from 1 plant with 9 leaves at the beginning to 15 branches with 82 leaves at the second week. The most effective control measure was by spraying with paraquat herbicide at the rate of 100-200 g ai/rai (6.25 rai = 1 ha), mixed with wetting agent.

During the 2009 fiscal year, the Plant Protection Research and Development Office, DOA, was permitted to conduct a project on "Surveillance on Crop Pests". Giant salvinia was one of such plants. The objectives were to keep pests with high risk to spread in the Kingdom under quarantine and to extend the knowledge on quarantine pests that may cause damage to the Kingdom

5.3 The Present State of Aggressiveness of Giant Salvinia

Although giant salvinia creates a lot of problems in some 20 countries around the world, it is still not quite serious in Thailand, as it does not create a problem in running waterways. This is because of the awareness and with the effective surveillance program, people are aware of its danger and do not bring it for cultivation in the ponds and aquariums. Only in two areas the giant salvinia is spreading rather seriously (Editorial Staff, 2010), namely:

5.3.1 In the South: Probably accidentally introduced from Malaysia, it completely occupies the whole area of 80 rai (12.8 ha) of a pond in Sadao District, Songkhla Province. The officers of the DOA had warned the people of its danger and had given advice on its eradication, together with a surveillance program after eradication practice. It was also present in Khlong La Chuang, Mok Muang Sub-district, Khlong Hoi Khong District, Songkhla Province. The villagers jointly eradicated it in November 2009, but without any surveillance program and pulling it out from the water, thus it has spread widely once again there. At present, the village head understands the situation. He informed the villagers and asked them to help in the eradication practice and the surveillance program.

5.3.2 In the Central Part: It is present in Mae Klong Dam, Tha Muang District, Kanchanaburi Province, which irrigates agricultural areas of 7 provinces, namely Suphan Buri, Kanchanaburi, Nakhon Pathom, Ratchaburi, Samut Sakhon, Samut Songkhram and Phetchaburi. In addition, it is also found spreading along Mae Klong River in Tha Muang District all the way to Mueang District of Samut Songkhram. The probable cause of distribution was the accidental escape from cultivation of the specimens growing in the aquariums in Kanchanaburi.

5.4 Recommended Control Measures

The common practice presently used is by manual labor. Mechanical eradication is done through the government agencies such as the Irrigation Department and the municipalities. The Department of Agriculture does not have the policy to use chemical control to eradicate giant salvinia as this may have ill effect on the health of the people and aquatic lives. The effective herbicide is paraquat. As Thailand has not imported diquat that has been used in other countries, the DOA recommends the use of paraquat only in areas with turbid water or directly onto the plants close to the bank.

5.5 Suggested Control Measure of Giant Salvinia

If found in any water body, remove it from the water, dry it and burn it. Those that remain along the bank of the water body, spray directly on it with paraquat herbicide at the rate of 100-200 g ai/rai, mixed with leaf surfactant adjuvant. Keep monitoring it after the first spray. If a few branched, the remains start to grow, then re-spray once again, at least once a month until no sign of its growth is observed.

After eradicating it by taking giant salvinia biomass out of the water, there is a need to have surveillance. If broken pieces are found, which can rejuvenate into whole new plants, they should be collected and destroyed. The use of paraquat chemical is allowed in turbid water in which clay particles are dissolved, since paraquat is inactivated by the clay particles after being bound. It is not recommended to be used in other conditions as most chemicals are harmful to the environment.

Any citizen who finds giant salvinia growing in any land should notify the owner to eradicate it, or notify the Weed Research Group of the Office of Plant Protection Research and Development, Department of Agriculture, Tel. 02-940 7409 or 02-940 7194, E mail: <www.ws.doa@doa.in.th>.

6. Discussion

6.1 Potential Threat

Giant salvinia is a potentially serious aquatic weed. It has been reported in more than 20 countries. Mitchell and Tur (1975) reported that it took only 3 years after Kariba Reservoir in Africa was in operation for giant salvinia to blanket 21.5% or 1,003 km^2 of the reservoir's surface area. Creagh (1991) wrote, "A single small plant may grow to form a thick mass covering more than 100 sq. km in just three months - choking lakes and waterways, reducing populations of aquatic plants and animals and in some countries threatening the livelihoods of thousands of people".

6.2 The Danger of Giant Salvinia

Giant salvinia causes the change in water resources in various ways, particularly from its rapid growth which expands and covers original indigenous plant species. The damages caused by the giant salvinia can be categorized as follows:

6.2.1 Not allowing light to pass through: Giant salvinia grows into thick mass, inhibiting sunlight to penetrate through the water body to the deep-seated submerged aquatic weeds such that they do not have enough light for photosynthesis.

6.2.2 Depletion of oxygen: Giant salvinia reduces the amount of oxygen of the water body through the disintegration of organic matter of the biomass of dead plant material which sinks to the bottom of the water. This action depletes oxygen dissolved in the water, causing death of fish and other aquatic lives.

6.2.3 Making the water body shallow: The accumulation of the remains of the giant salvinia in the bottom of the water makes the waterways shallow.

6.2.4 Provide habitat for weeds to grow: Giant salvinia which forms thick mass is an anchor place for weed seeds blown in the air to germinate and grow; or noxious climbing weeds from the bank can occupy the water body where giant salivinia grows. Other aggressive plants species can replace the original ones which have been extinct.

6.2.5 Loss of animal species: As the water body becomes shallow with the loss of original plant species, aquatic animals suffer to the extent that they finally disappear.

6.2.6 Making water resources un-utilizable: The thick dense mass of giant salvinia completely covers the body surface, which, in addition to slow down the water flow, also impedes with navigation. It blocks the water flow such that not enough water can pass for irrigation of the agricultural land and for hydroelectric power generation.

6.2.7 Transmitting infectious diseases: The mass of giant salvinia is an ideal habitat for mosquitoes which transmit infectious diseases such as mansonia in Sri Lanka, malaria in Papua New Guinea, as well as encephalitis and dengue fever elsewhere.

6.2.8 Economic impact: Eradication of giant salvinia in various water sources requires a lot of budget and labor.

6.3 Utilization

One way to fight against the giant salvinia is through its utilization. Howard and Harley (1998) had done some experiments to make use of its biomass for mulch, compost, fodder, paper making, handcrafts and bio-gas generation. They estimated that the annual gains from such operation worldwide are approximately $US 150 million. The main obstacle to the commercial use of the giant salvinia is its high water content, which is often up to 90% of the harvest wet weight. Its high growth rate may lead to an optimistic evaluation of its commercial use, but the commercial benefits are negligible in comparison to its known wide-ranging negative socio-economic and environmental impact (Julien *et al*. 2002).

6.4 Lesson to be Learned

Giant salvinia is not the first case of plant introduction that later turned out to be noxious invasive plant. In spite of having the Act prohibiting its introduction and cultivation, it is still found spreading in the Kingdom. Its introduction as ornamental plant in the aquariums is to be blamed and the law enforcement should be put into action. Otherwise, more and more alien plants will be introduced and turned into noxious invasive weeds.

7. Acknowledgements

The author wishes to thank Ms. Panni Wichachu, Editor, DOA's Kasikorn Journal, and Mr. Wirat Chantarasmi of the Horticultural Science Society of Thailand for providing information. He is grateful to Dr. Siriporn Zungsontiporn, Weed Research Group, Plant Protection Research and Development Office, DOA for the most valuable information used in this contribution, and for her critical review of the manuscript.

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