Water Hyacinth Infestation in Ponds and Satellite Lakes in the Lake Victoria Basin on Tanzania: Status and Efforts to Manage it.

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Abstract

A survey was conducted in ponds and satellite lakes in the lake Victoria basin in March 2000 to ascertain the presence of water hyacinth and its effect to the communities and the environment. Out of 14 (12 ponds and 2 satellite lakes) surveyed, water hyacinth was found in 11 ponds (i.e. 91.7% of ponds) and there was no water hyacinth in the satellite lakes under study. The highest (31.5 ha) infestation was recorded at Ngulyati pond in Bariadi, Shinyanga followed by Bukabwa (8 ha). No water hyacinth was found at Sarawe pond, Itabagumba and Buswahili satellite lakes. Plant population varied significantly ($P < 0.001$) with the highest (196 plants/0.25m^2) recorded at Bukabwa and the lowest (21/0.25m^2) at Bunda ponds. The immediate effect of the water hyacinth infestation in the ponds included difficulty in accessing water for domestic use owing to the extensive water hyacinth mats and loss of water through evapotranspiration. In the efforts to control the weed, water hyacinth weevils' *Neochetina eichhorniae* and *N. bruchi* were released in 7 of them (9,600 adult weevils in 5 ponds at Mwanza Prison Center and 44,000 and 52,600 at Bukabwa and Ngulyati ponds respectively) which have established and multiplied to a level of up to 8 weevils per plant causing feeding scars of 38.65 on average at Ngulyati. Weed population decreased significantly ($P<0.05$) owing to the insect-induced stress. Other dominant aquatic weed species found growing in the ponds included *Ceratophylum dermesum, Pistia stateotes, Rapa natas* and *Brasenia SP* at Buswahili Satellite Lake and *Cyperus* spp and *Justicia* spp *in* the rest of the ponds and Satellite Lake. The presence of water hyacinth in the ponds and satellite lakes has partly contributed to water hyacinth re-growth (resurgence) in lake Victoria and other water bodies in the lake basin. Therefore management strategies of water hyacinth in Lake Victoria should also include ponds and satellite lakes.

Key words: ponds, satellite lake, water hyacinth, infestation

Introduction

Water hyacinth (*Eichhorniae crassipes* [Mart.] Solms-Laub.Pontederiaceae) has become a worldwide problem throughout equatorial regions, causing life-threatening conditions in some places (Julien *et al*., 1996). The weed is invasive in aquatic ecosystems of the Southern America as well as most tropical and sub tropical areas (Center e*t al*., 1999). Water hyacinth was gazetted as a noxious weed in Tanzania in 1955 after its first appearance in the river Sigi in the same year (LVEMP, 1999). Since its first appearance in the lake Victoria in 1987 water hyacinth has continued to invade water bodies and wetlands in most areas in the lake basin. Problem caused by water hyacinth are well documented (Center, 1994; Ndunguru *et al*., 2001). By using integrated pest management strategies such as biological control, manual removal, quarantine regulation and training, water hyacinth infestation in Lake Victoria, has been reduced by 78% (Mallya *et al*., 2001).

Water hyacinth management in lake Victoria can only be successful if ponds and satellite lakes in the lake basin are kept free of the weed. Early in the year 2000, local communities residing near various ponds and satellite lakes in the lake Victoria basin reported to LVEMP, of water hyacinth infestation in some of the ponds and lakes. Water hyacinth was denying the communities access to water for domestic use and was making fishing almost impossible. This survey was therefore undertaken to ascertain the presence of water hyacinth, assess its status and propose, appropriate control measures. The results of the survey are detailed in this paper.

Materials and Methods

Survey Procedure

A total of 12 ponds and 2 satellite lakes in the lake Victoria basin in Tanzania were selected based on the information given by the local communities and a rapid survey, by the research team, to ascertain the presence of water hyacinth. Water hyacinth was sampled from 6 sites selected randomly after estimation of the pond/satellite lake size. At each site, a 0.25 m^2 (0.5 x 0.5 m) frame was dropped at five points on the mat and plants in the enclosed mat segment were counted. One plant from the mat was removed and the following parameters were measured; length of the longest root, petiole length, lamina width (of the second youngest leaf), number of ramets (stoloniferous offsets bearing roots or root initials), number of weevil feed marks if any. Total water hyacinth coverage was also determined based on the size of the pond or satellite lake. Members of the local communities residing near the ponds/satellite lakes were interviewed to obtain information regarding the history of the pond, how the water hyacinth infestation affected their daily life and the environment. Photographs of the water hyacinth were taken for comparisons with the existing infestation elsewhere.

Weevil Release and Impact Assessment

9600 adult weevils (*Neochetina eichhorniae* and *N. bruchi*) were released in 5 ponds at Mwanza Prison Center, 44,000 weevils at Bukabwa and 52,600 weevils at Ngulyati ponds in April 2000 by the authors in collaboration with the communities. The *Neochetina* weevils however, were not released at Bunda ponds because of frequent draughts in that area.

Impact assessment started in June 2000 by visiting the ponds where weevils were released. Data collection involved monitoring the weevil population, water hyacinth population, growth parameters of the weed, and the overall weed coverage monthly for 12 months.

Data analysis

Analysis of variance (ANOVA) was used to compare means of the parameters for the different ponds using a Descriptive statistics in a Microsoft Excel Computer Programme.

Results

Water Hyacinth Infestation

Water hyacinth was found in 11 ponds out of 12 (i.e. 91.7% of the ponds)%) and there was no water hyacinth in the 2 satellite lakes. The highest (31.5 ha) water hyacinth coverage was recorded at Ngulyati pond in Bariadi, Shinyanga with a size of 35.5 ha (i.e. 88.7% coverage). This was followed by Bukabwa pond with 8 ha of water hyacinth infestation (Table 1). Plant population varied significantly ($P<0.001$) from one pond to the other. Water hyacinth was not found at Sarawe pond, Buswahili and Itabagumba satellite lakes in Musoma and Sengerema district, respectively. The 4 ponds located at Bunda district had water hyacinth infestation comprised of short plants with many flowers. Plant population in these ponds averaged 21/0.25 m^2 (Table 1). At Prison center, some water hyacinth plants had weevil-feeding scars that ranged from 3 to 43 per plant. The attacked plants were girdled at the narrow junction of the blade, which resulted in curled leaf margins.

Table 1: Water hyacinth demographics in ponds and satellite lakes before weevil release

Name of the pond/Satellite lakes	Mean weed cover (ha)	Mean plant population/ 0.25m^2	Mean petiole length (cm)	Mean root length (cm)	Ramets/ plant	Weevil feeding scars/plant
Mwanza Prison Centre (5 ponds)	0.2-1	35	28	20	1.4	0
Ngulyati	31.5	41	39	49.6	1.98	23
Bunda (4 ponds)	0.2	21	14	27	2.0	0
Bukabwa	8	196	27	43	3.0	0
Buswahili	0	-	-	-	-	-
Itabagumba	0	-	-	-	-	-
Sarawe	0	-	-	-	-	-

At Bukabwa Satellite Lake, the dominant aquatic weeds found were *Ceratophylum dermesum*, *Rapa natas* and *Brasenia* sp. Itabagumba Satellite Lake consisted of mainly *Cyperus* spp and *Justicia* spp. The coverage was about 70% and 90% at Buswahili and Itabagumba, respectively. Only *Pistia* spp. was found at Sarawe pond.

Effect of Water Hyacinth Infestation to the Communities

In all the ponds where water hyacinth was found, the communities experienced varying problems, for example, at Bukabwa pond, the weed had resulted in a serious water shortage and fishing in the pond was no longer possible. The communities had to walk approximately 10 km in search for drinking water. Water hyacinth infestation at Ngulyati pond (31.5 ha) had denied easy access to water by the communities and the water quality in this pond, in terms of colour, smell and taste, was completely degraded. During heavy rains water hyacinth is washed into neighbouring rice fields causing poor rice germination and establishment. The communities at Mwanza prison experienced similar problems.

Weevil Release and Impact Assessment

A 12 months impact assessment data analysis revealed good establishment of the weevil and significant ($P<0.05$) reduction of the weed population. Results of the impact assessment for Ngulyati pond are presented (Table 2). Plant population was reduced to 11 ± 0.73-plants/0.25 m^2. Weevil feeding scars reached 38.65 ± 4.5 per plant on average (Table 2). At Bukabwa pond, weevil-feeding scars averaged 36.4 per plants. At Mwanza prison center weed population reached 22 ± 0.62 plants/0.25 m^2

Table 2. Water hyacinth status at Ngulyati pond 12 months after weevil release

Parameter assessed	Mean (N=30)	Minimum	Maximum
Plant population/0.25 m^2	11.75 ± 0.73[a]	5	17
Petiole length (cm)	11.07± 0.07	5	16
Root length (cm)	32.9 ± 2.7	10	56
Live leaves/plant	7.9 ± 0.28	6	10
Lamina width (cm)	6.2 ± 0.18	5	8
Weevil feeding scars/plant	38.65 ± 4.5	8	71
Ramets/plant	1.6 ± 0.33	0	5

[a] Mean ± standard error

Comparison of Water Hyacinth Infestation Before and After Control Measures

In all the ponds where water hyacinth weevils were released, weed population and petiole lengths were reduced significantly (Figs. 1 and 2, respectively). The highest reduction (76%) in plant population (from 196 to 47 pants /0.25m^2) was recorded at Bukabwa.

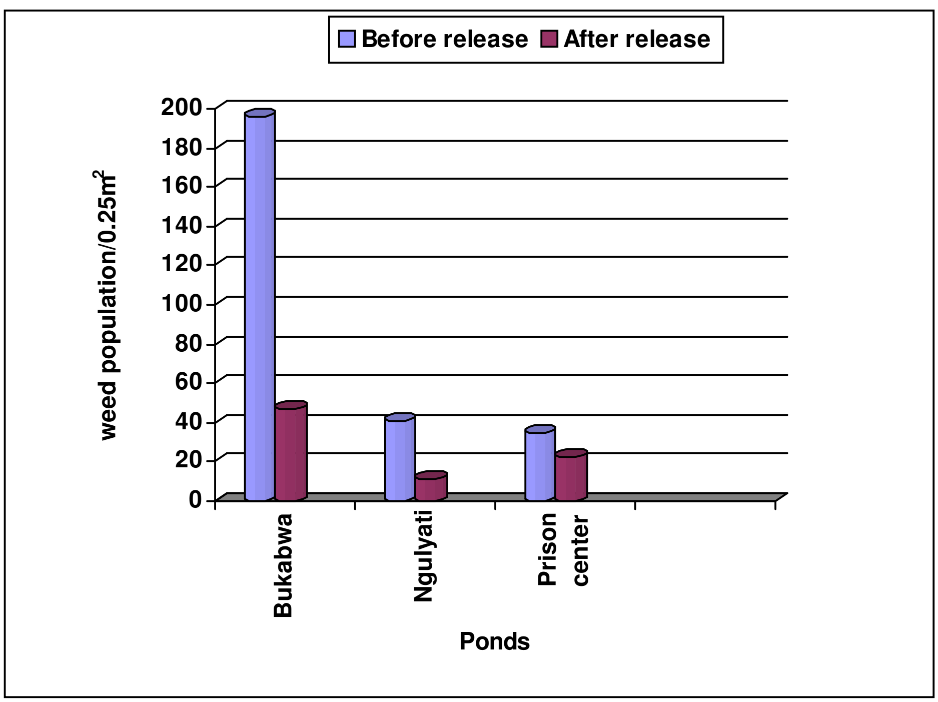

Fig. 1: A comparison of water hyacinth population at three ponds before and after weevil release

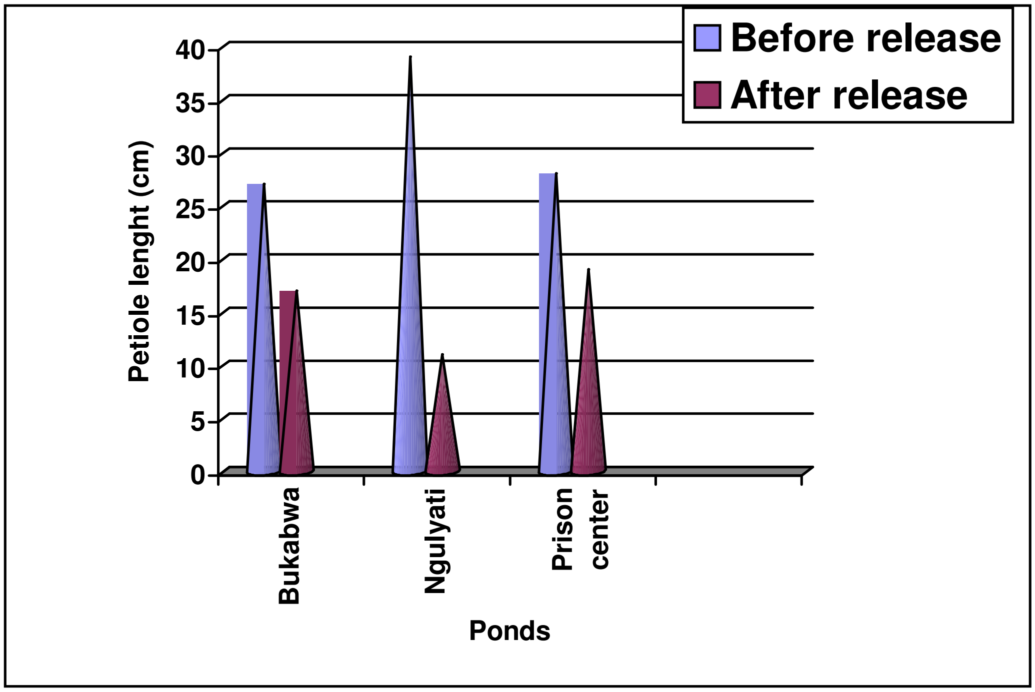

Fig. 2: Comparison of water hyacinth leaf petiole length before and after weevil release

Discussion

This study has confirmed the presence of water hyacinth in some ponds in the Lake Victoria basin. Water hyacinth however was not found in two satellite lakes (i.e. Itabagumba and Buswahili) and Sarawe pond. Plant population was higher at Bukabwa than Ngulyati pond partly because initial infestation started as early as 1994 at Bukabwa whereas infestation in Ngulyati is believed to have started four years later i.e. in 1998. The absence of weevils at the initial infestation in the two ponds allowed time for the plants to grow into extensive mats. The ability of the weevils to impair the water hyacinth growth and consequently suppress water hyacinth mat expansion has been demonstrated by other researchers (Center, 1999; Ndunguru *et al*, 2001).

Water hyacinth population in the other ponds at Bunda and Prison centers was moderate (Table 1). However, the extensive flowers observed in these ponds coupled with a relative small size of these ponds suggest that there is a presence of huge seed reserve that would contribute to weed re-growth, re-infestation and spread in the future. The mean petiole length, root length and lamina width observed during this study correspond to those reported elsewhere (Jayanth, 1988).

In the absence of insect induced stress on water hyacinth, the weed may spread to cover a bigger surface area of a water body with consequences of increased water losses through evaporation and evapo-transpiration, and impaired access to the remaining part of the water body and degraded water quality. In Egypt, for example, water hyacinth infestation in various water bodies caused water loss of up to 3.5 billion cubic meters per year through evapo-transpiration (Fayad, 2000).

Following weevil release, in the water hyacinth infested ponds, tremendous suppression of weed growth has been realized. At Ngulyati, Bukabwa and Prison center, the weevils clearly helped to control the water hyacinth. Weed population and plant petiole length decreased significantly (Figs. 1 and 2) owing to the insect-induced stress as reported early (Center, 1987; Center e*t al*., 1999; Ndunguru *et al.*, 2001). The average number of scars on a selected leaf correlates with the average number of adult weevils (Center and Durden, 1986). In this study the mean feeding scars mirrored the weevil population (i.e. the higher the number of weevils the higher the number of scars).

Successful weed biological control agents do not necessarily cause direct mortality of the target plant. As insect-induced stress became apparent particularly at Bukabwa pond, population of other aquatic weed (*Cyprus* spp.) increased. This scenario has been clearly demonstrated by Kok (1993) who found that the impact of weevil is subtle and of a long-term nature, leading to gradual reduction in the water hyacinth vigour and thus increasing its susceptibility to competition from other aquatic vegetation.

Water hyacinth exhibiting high insect-induced stress (scars of up to 71) probably allocated few resources to productivity as illustrated by low number of ramets (Table.2) and eventually low plant density. The presence of weevil feeding scars in the ponds at Mwanza Prison Center before weevil release suggest that weevil infested hyacinth plants were introduced in the ponds. The communities confirmed this observation that water hyacinth was introduced accidentally from Lake Victoria (where weevils had been released) by people who were collecting hyacinth from the Lake to feed their domestic animals.

Conclusion

This study has ascertained the presence of water hyacinth in water bodies other than lake Victoria in the lake basin. Human activities such as fish trading have partly contributed to the distribution of the weed, for example fishermen use water hyacinth to cover their fish in the carrying baskets. These results therefore argue strongly for a further investigation of hyacinth infested ponds in the Lake Victoria basin so that weed control measures can be taken. Should the spread of water hyacinth in the ponds continue, efforts to manage the weed in Lake Victoria will not bare fruits due to continuous presence of water hyacinth source which will facilitate . continuous re-infestation and resurgence. There is a need to train the communities living around the ponds and satellite lakes on water hyacinth infestation, its effects and the control strategies so as to minimise unintentional spread of the weed.

Acknowledgement

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Water Hyacinth (*Eichhornia crassipes)* Management in Lake Victoria: Update on Infestation Levels

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Abstract

Efforts to control water hyacinth (*Eichhornia crassipes* [Mart.] Solms-Laub infestation begun in Lake Victoria on Tanzanian side in 1997 to control 2000 ha of the invasive weed by releasing water hyacinth weevils-*Neochetina eichhorniae* and *N. bruchi.* Water hyacinth was sampled from 117 sites in Lake Victoria in May 2001 to assess water hyacinth infestation and the impact of the released weevils on the weed. The survey revealed only localized water hyacinth infestation before the weevils were released. 78% of the weed was reduced by the weevils. Plant population averaged only 11.3 ± 0.73/ 0.25 m^2 with petiole length of 14.9 ± 1.04 cm. The water hyacinth plant lamina width reached 7.6 ± 0.39 cm on average. The mean ramets/plant was 1.6 ± 0.14. Both the weevil species *N. eichhorniae* and *N. Bruchi* established well with mean population of 8 adults/plant. The weevil adult feed marks was 14.2 ± 2.2/plants on averages both on release and recovery sites. A biological control has been recommended as a successfully management strategy for the control of water hyacinth infestation in Lake Victoria in Tanzania.

Key words: Lake Victoria, *Neochetina* weevils, Tanzania, Biological control, weed coverage.

Introduction

Water hyacinth-*Eichhorniae crassipes* (Mart) Solms (Pontederiacea), is the worst aquatic weed in Tanzania. Recently, the weed has spread faster in various fresh water bodies with serious infestation recorded in the Lake Victoria (Labrada, 1995). The weed has posed a serious environmental and socio-economic problems related to the use of and management of natural resources.

Several control measures have been tried to control the rapid growth of the weed, one of them being the use of *Neochetina eichhorniae* and *N. bruchi* which were released in 1997. This survey was conducted to assess water hyacinth infestation and impact of the weevils.

Materials and Methods

Monitoring the establishment, spread and impact of the *Neochetina* weevils was done by 0.25 m^2 (0.5 m x 0.5 m) quadrant monitoring from a boat. In May 2001 a total of 117 sites were sampled for impact assessment. At each site 0.5 m x 0.5 m frame was dropped on the mat at different points and three plants from the enclosed mats were removed and assessed for plant and weevil characteristics. To avoid irregular results due to edge effects, sampling was done only within the water hyacinth mats. Measurement were taken for plant population per 0.25 m^2. On each individual plant; number of living leaves, number of ramets (stoloniferous offsets bearing roots or root initials), petiole length (of the second youngest leaf), lamina width and root length were recorded. Contemporary weevil feeding damage, adult weevil feeding scars and weevil population were also counted. Additional information included name and coordinates of the location and weevil species. Observations were also made of larvae damage (presence of streaks of necrotic tissue just beneath the epidermis of petioles) and the nature of the weed if in pure stand or growing in association with other aquatic weeds.

Data analysis

Arithmetic means of the parameter were compared using Analysis of Variance (ANOVA) in descriptive statistical analysis using a Microsoft Excel Computer Program.

Results

This study has revealed reduction of water hyacinth infestation by 78% (from 2000 to 440 ha). Out of the 117 sampled sites 26 (22%) had water hyacinth infestation, other 14 (12%) new sites showed resurgence mainly from seed germination. Infestation was mainly observed in gulfs and bays. Water hyacinth were also found at the inlets of the rivers Kagera and Mara. Plant population in the infested sites was low averaging only to 11.31 ± 0.73 plants per 0.25 m^2 (mean ± SE) (Table 1). The population, however, varied significantly ($P < 0.05$) among different sites with the highest population of 42 and lowest of 0 plants/0.25 m^2. There was no discernable difference in the plant population in the release and recovery sites (where weevils had not been released). Water hyacinth plants exhibiting insect-induced stress were observed throughout the infested areas. They had curled and desiccated leaves; thin petioles that were brittle and generally appeared water soaked. Water hyacinth flowers were rare to find in such sites.

Table 1: Water hyacinth demographics in Lake Victoria

	Parameter	Mean	SD
1	Plant population	11.3	0.73
2	Weed coverage (M)	4.0	0.38
3	Root length (cm)	19.6	1.41
4	Leaf length (cm)	14.9	1.04
5	Number of leaves/plant	6.3	0.31
6	Lamina width (cm)	7.6	0.39
7	Number of feeding scars	14.2	2.28
8	Number of ramets/plant	1.6	0.14

Both *Neochetina eichhornia* and *N. bruchi* were found at every site where water hyacinth was present. The number of adult weevils was 8 ± 0.65 on average and at times reached 12 per plant. The number of ramets per plant was low (1.63 ± 0.14) and mean adult weevil feeding scars was relatively high (18.0 ± 2.0) (Table 1). In some areas where water hyacinth plants were relatively healthy, weevil adult feeding scars reached up to 156 per plant and were observed on both leaf blade and the petioles. There was also evidence of larvae damage including tunnelling within the plant tissues and presence of streaks of necrotic tissue beneath the epidermis of petiole. The mean plant leaf lamina width and root length were 6.9 ± 0.59 and 12.0 ± 0.8 cm, respectively. Most of the sampled sites in Bukoba, Muleba, Biharamulo and Ukerewe Island were free from hyacinth infestation whilst most infections were recorded in Misungwi, Mwanza, Magu, Bunda and Musoma

In many instances particularly where water hyacinth was severely damaged by the weevils, ecological succession whereby water hyacinth was invaded by other aquatic weeds, such as water sedges (*Cyperus* spp.) and Hippo grass (Vossia *cuspidator*) was very common. . Pure water hyacinth plant stand was observed mainly where weevil damage was relatively low.

Discussion

This study has recorded 78 % reduction in water hyacinth infestation in a period of 1 year, slightly higher than the 70% recorded in the previous survey (Mallya *et al*., 2001). This suggests that the noxious weed is now being brought into a manageable level.

The characteristics of the insect induced stress observed in this study correlated well with those reported by Julien *et al.,* (1999), who observed that heavy feeding by adult weevils on the lamina causes leaves to desiccate and curl and larvae cause presence of tunnels and streak of necrotic tissue just beneath the epidermis of petioles.

The presence of water hyacinth mainly in gulfs, bays and in the fringing wetlands, indicate that the tranquil nature of these places, whereby plants are sheltered from strong wind and wave actions facilitates uninterrupted weed growth. This situation was also reported by Twongo (1999), who observed that shore line environment suitable for establishment and proliferation of water hyacinth in Ugandan side were sheltered from violent off-shore and along the shore wind and wave action.

The absence of water hyacinth infestation in most sampled areas in Bukoba, Muleba, Biharamulo and Ukerewe Island could be attributed to the nature of their shoreline, which is steep and rocky. Incoming mats have no support for growth and rooting. Also most of the sand beaches were found free of water hyacinth infestation.

The low mean water hyacinth plant population of 11.31, number of ramets per plant (1.16), lamina width and root length of 7.6 and 19.6 respectively can be attributed to a constant stress imposed by the high number of adult weevils which averaged 8/plant. The same situation was also reported by Wright (1995) and Ndunguru *et al*., (2001) who observed that, weevil's establishment caused increasing level of weevil damage, decreased plant and infestation dimension and subsequently death.

The observed resurgence of 12% is presumably emanating from the seed reserves and the incoming plants from the rivers Kagera and Mara. This suggests that the war against water hyacinth is far from over. Plant re-growth produces healthy, vigorous plant population that grow to problem proportions very quickly. This may be attributed to the loss of biological control agents (the weevils) that follow suppression of the weed. This has also been reported elsewhere (Center *et al.*, 1999) who observed that loss of plants results in severe reduction in biological control agents, so that few weevils are present when the regrowth cycle starts.

There was no distinguishable difference between water hyacinth plant populations in the released and recovery sites that could be explained by the mobility of water hyacinth mats. Mats detach from released sites and been carried by winds and water currents to unreleased sites (Twongo, 1999) and therefore causing comparatively an equal distribution of the released weevils.

Conclusions

The beneficial impact of biological control of water hyacinth has been demonstrated in the lake Victoria in Tanzania. Water hyacinth infestation has been tremendously reduced over a period of four years. However, there is a continuous inflow of water hyacinth (0.2 ha per day) into lake Victoria from river Kagera and a substantial amount from river Mara. Resurgence (re-growth) of water hyacinth has been observed in the managed areas mainly from seed reserve.

Recommendation

i. Since water hyacinth resurgence in Lake Victoria might as well develop potential to disrupt aspects of the national economy it is recommended that continuous management of the weed, especially using biological agents, should be an ongoing undertaking.
ii. Continuous monitoring of establishment, spread and impact of control agent should be implemented as it provides information on the effectiveness of an agent in establishing and reducing the weed problem, and allows assessment to be made of the potential effectiveness of the agent if introduced to other regions (Julien *et al.,* 1999).
iii. As part of biological control release on water hyacinth the following information need to be established the rate of natural spread of agent, the time taken for the agent to reach a damaging population, and the progressive impact of the weed infestation and the eventual level of control achieved, (Julien *et al*., 1999).

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