International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 7; Issue 1(E); January 2018; Page No. 9013-9020
DOI: http://dx.doi.org/10.24327/ijcar.2018.9020.1474

Research Article

CONTROL OF WATER HYACINTH (*EICHORNIACRASSIPES*) USING WEEVIL

John D and MerlineSheela A

Centre for Environmental studies, Anna University, Chennai – 600 025

A R T I C L E I N F O

Article History:
Received 18th October, 2017
Received in revised form 10th November, 2017
Accepted 06th December, 2017
Published online 28th January, 2018

Key words:
Water hyacinth, Biocontrol, *Neochetinaeichornia, Neochetinabruchi*

A B S T R A C T

This study is related to the assessment of bio-control potential of *Neochetina spp.* Weevils on the weed *Eichhorniacrassipes.* The outcome of the study indicates treatment with two weevils per plant are most effective in controlling the aquatic weed, the reduction phenotype characters of *Eichhormiacrassipes* namely, plant density, biomass (31.3%), petiole length (28.42%), Plant height (28.42%) root length (10.54%) and leaf length (9.79%) leaf width (7.46%) in the period of 90 days. Numerous feeding scars observed in the first 15 days, and production of ramets or re-sprouts were greatly reduced by the introduction of *Neochetina*spp weevil. The results are encouraging and it is calculated that 3000 weevils are required for effective control of water hyacinth in the water spread of one hectare coverage. Also the water quality analysis was performed to find the impact of decay of *Eichhormiacrassipes* on the effect of thephysical factors such as wind velocity, temperature, light and water flows does not affect the bio-control potential of the bio-control agents *Neochetina spp.* Weevils are capable of sustainable to the tropical climate of Tamilnadu state.The biological treatment is environmentally safe, sustainable and self perpetuating.

INTRODUCTION

The Aquatic Weed is those unwanted vegetation which grows on water and hamper its use. In India, many rivers, irrigation canals, lakes both man made or natural are choked by the explosive growth of aquatic weeds, resulting in enormous direct losses. The most important aquatic weed is *Eichorniacrassipes* which is indigenous to Brazil (Monsanto, 1996). The aquatic weed Water hyacinth (*Eichhorniacrassipes* (Mart.) Solms – Laubach; Pontederiaceae) is an erect, free-floating, stoloniferous, perennial herb. It grows to 1 metre tall with buoyant leaves, which vary in size according to growth conditions. The bisexual flowers are blue with a central yellow area, borne on a single spike. Their beauty and appeal has encouraged intentional spread of the weed by man.

The weed's seriousness in its introduced range is a result of its rapid rate of growth, vegetative reproduction, ability to re-infest via the seed bank or flooding traffic, water quality, infrastructure for pumping and hydroelectricity generation, water use and biodiversity. Other problems include property damage during floods, water losses due to evapotranspiration and an increase in the population of vectors of human and animal diseases. Water hyacinth is now present in many countries of the tropics and subtropics and in most of these it has become the most serious floating aquatic weed.

Corresponding author:* **John D
Centre for Environmental studies, Anna University, Chennai – 600 025

The Problems caused by the aquatic weed Water Hyacinth are Impediments to flow in Open Channels, Blockage of Intakes, Micro habitat for variety of disease vectors, Water loss due to evapo- transpiration, Problems related to fishing, Reduction of bio diversity.

There are many ways to treat and control water hyacinth. The mechanical methods use cranes, conveyors and cutters, but the area required is large. Also more installation and operation charges are required (Villamagna, 2009). Chemical methods will be more effective and herbicides have long been used to control water hyacinth (Terry, 1991). But the chemicals kill other aquatic life. So, biological methods are an alternative to replace mechanical and chemical methods. In the present study an attempt is made to study the impact of the bio control agent weevil on the growth of water hyacinth so that it could be exploited to control the weed in water bodies.

MATERIALS AND METHODS

Bio control agents

Bio control agents (*Neochetinabruchi, Neochetinaeichornia*) wereobtained from National Bureau of Agricultural Important Insects, Bengalaru transported, preserved and reared in the Insectary.

N. bruchi: The body is broad, robust and densely covered with fused brown and tan scales. The tan scales form a V-shaped chevron on the back that distinguishes this species from

N.eichhorniae. Antennae and lower leg segments are reddish brown there are yellowish water-shedding scales on the leg joints and parts of the underside. The shout is thick and weakly curved to straight in males; in females it is longer, more slender and more curved. Male length is about 3.5 mm long (excluding head) and female length is about 4.5 mm long (excluding head). The female shout is noticeably shiny near the tip where the scales have been rubbed away. This easily distinguishes females from male in both species. The overview of methodology is given in Fig.1.

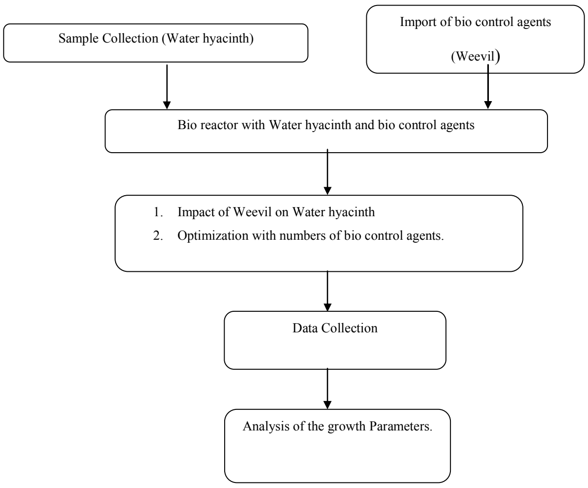


Figure 1 Overview of Methodology

Fig 2 *Neochetina bruchi&Neochetina eichornia*

Collection and transportation of the weevil

The weevils *N.eichornia* and *N.bruchi* (Fig.2) were initially collected from National Bureau for Agriculturally Important Insects Tank at Bangalore. The weevils were packed and transported as suggested by Jayanth (1988). The insect packing units were prepared from PET bottles with screen at the top. Two bouquets of *E.crassipes* leaves were provided inside the PET jar for adult feeding. The bouquets were prepared by collecting 15 leaves with 10 cm long petioles and the cut ends were wrapped with a thick wad of cotton wool. The mouth of the jar was tightly closed. The adult weevils were then released inside and the open end of the cover was tightly closed.

Mass multiplication of the weevils

For mass multiplication of the weevil the method suggested by Jayanth and Singh (1993) was followed. About 25 *E.crassipes* were placed in plastic basins of dimension 60 cm x 40 cm x 30 cm on which 50 adult weevils were released into outdoor tanks. The collected adult weevils were reused for exposing fresh plants. The adults emerging were collected at fortnightly intervals.

Water Hyacinth

Water Hyacinth samples were collected from the Velachery tank, Cooum River on the random basis. The collected samples were grown in the plastic tub.

Materials required for the experiment

1. Aquarium for the Water hyacinth plant rearing.
2. Insectaries for the Biocontrolagents' preservation and rearing.
3. Testing facilities for the abiotic factors of water and to measure the parameters of growth, (Biomass, height, Spread area, etc.)
4. Bioreactor 85 litres capacity 16 nos. for testing under different conditions
5. Insect screen

Experiment setup

The lab-scale Sequencing Batch Reactor wasdesigned based on the studies conducted earlier and the size of the reactor is arrived at (Marlin *et al*., 2013). The Total Volume of the reactor is 85L with the diameter of 60cm and height of 30cm and it is made of Plastic material. Working volume is 75 L.

The experiment was conducted with the following treatments
T_1- Control (water hyacinth alone without weevil)
T_2 - weevils/plant
T_3 - weevils/plant
T_4 - weevils/plant

The study was conducted in the laboratory conditions in plastic troughs (85litre capacity). Into each of the troughs two pre-weighed water hyacinth plants were transferred and added with water to prevent the plants from drying. The weevils of *N. bruchi, N. eichhorniae* were introduced into each trough (2, 4 and 8 weevils/plant). The plastic troughs were covered with wire mesh, to prevent the weevils from escaping as well as to prevent the interference of other plant pests. The setup was left undisturbed until the complete wilting of the plants or 90 days. During the experimental period, the growth parameters of the plants were recorded every week, from this the percent biomass reduction wascalculated. Control troughs weremaintained with only water hyacinth plants. For each treatment three replications were maintained.

Data Collection

The data required for assessing the impact of *Neochetinasp*p weevils on Water hyacinth wereassessed and the following parameters wereobserved periodically every week. The data from the control and three experimental setup were assessed.

1. Plant biomass
2. The Petiole length

3. Root length
4. The percentage of surface area covered by Water Hyacinth
5. The plant density no/sq.m
6. Plant density – weighted (No/sq.m * coverage)
7. leaf area, No. of scrappings
8. Daughter plant production

The observations were recorded every week and tabulated as mentioned in table -1 for all the treatments. The growth parameters weremeasured physically with weighing balance and measuring scales.

RESULTS AND DISCUSSION

The impact of weevils on water hyacinth were analysed statistically based on the collected data. Analysis of data were done for all the parameters using ANOVA, paired t-test for all the treatments.

Laboratory studies were carried out to determine the effectiveness of the bio-control agents on Aquatic Weed – *Eichorniacrassipes* phenotypic characters. Different experiments have been carried out using adult *Neochetinaeichornia* and *Neochetinabruchi.* The results of the laboratory investigation have been given here under.

The experiment was conducted in the State Level Aqua culture Laboratory at Chetpet, Chennai. Two plants in each pot were labeled for periodic observations at weekly interval except for feeding scars which was observed at 3 days interval. The phenotypecharacters ofthe plants infested with three different inoculation loads of *N.bruchi /N.eichhorniae* were tried viz., two insects per plant (T1), four insects plant (T2), and eight insects plant (T3) were noted and recorded.

E.crassipes plants were found to collapse within one week when they were grown in pots containing bore well / tap water, due to deficiency of nutrients. In order to correct this nutrient deficiency the nutrient supplement of cow dung (200 g), superphosphate (40 g) and urea (10 g) was added as suggested by Jayanth and Singh (1993).

Every week the growth parameters *viz*., biomass, petiole length, Plant height, root length and leaf area, Number of scars and the production of ramets were recorded. It could be observed that the insects were able to survive during the different seasons of rain and heat.

Petiole Length

The petiole length was measured from the root top to the tip of the leaf andwas recorded. In Treatment -1 with two weevils per plant, the Petiole Length was reduced from 28.71 cm to 13.43 cm (28.42 %) in the period of 90 days whereas, the control sample shows an increase in growth of 30.5 cm to 39.25 cm (8.9 %), In the Treatment -2 with 4 insects per plant the treated plant shows the reduction of Petiole Length from 16.13 cm to 11.70 cm and the control sample shows an increase in Petiole Length from 12.93 cm to 16.45 cm(Fig.3), similarly in Treatment -3, with 8 insects per plant the treated plant shows the reduction of Petiole Length from 32.22 cm to 24.70 cm and the control sample shows a increase in Petiole Length from 30.5 cm to 32.5 cm(Fig.8)The results are in line with the experiment in Bellandur Tank in Bangalore (Jayanth and Nagarkatti, 1987) it was observed that the Petiole length was reduced from the initial value of 59 and 65 cm to 32 and 43 cm after a period of 20 month when observed in December, 1985 and with the experiment in Agram Tank in Bangalore (Jayanth, 1987) were it was observed that the Petiole length was reduced from the initial value of 60.5 cm to 27.6 cm after a period of 18 month when observed in September, 1985.

In the experiment in Kenya Lake Vitoria Basin Kenya (Ochieletal. 2001) Petiole length ranged from 21.4±2.1 to 36.5±1.6 cm Number of petioles damaged by weevil larvae ranged from medium, 3.8± 0.7 at Luanda Konyango, to high, 6.8±0.9 at Vusijo, near Sio Port. During the period, the plants were not as prolific as during the peak infestation period and a considerable decline in biomass was experienced.

Biomass

The weight of the *Eichorniacrassipes* were weighed and recorded. In Treatment -1 with two weevils per plant, the plant biomass was reduced to 175 g to 121.2 g (31.3 %) in the period of 90 days the control sample shows an increase in growth of 246.5 g to 264.7 g (8.9 %)(Fig.3), In the Treatment -2 with 4 insects per plant the treated plant shows the reduction of biomass from 121.1 g to 87.4 g and the control sample shows an increase in Biomass from 119.4 g to 134.31g(Fig.5), similarly in Treatment -3, with 8 insects per plant the treated plant shows the reduction of biomass from 265.62 g to 178 g and the control sample shows an increase in Biomass from 269.2 g to 290 g(Fig.6).

The reduction of biomass was also reported in the experiment in Kenya Lake Victoria Basin Kenya (Ochiel *et al*., 2001) out of the four sites where weevils were released Bukoma beach shows the reduction of biomass from 2270 g to 925 g in 110 days and the other three sites namely Suo Port shows an increase in biomass from 1685 g to 3550 g in 111 days, , Police Pear shows an increase in biomass from 251 g to 482 g in 174 days and Kendu Pier shows an increase in biomass from 1950 g to 2510 g observed in 112 days.

Plant Height

The plant height was measured from the water level to the tip of the plant and was recorded. In Treatment -1 with two weevils per plant, the plant height was reduced from 39.33 cm to 28.15 cm (28.42 %) in the period of 90 days whereas the control sample shows an increase in growth of 41.5 cm to 46.25 cm (8.9 %) , In the Treatment -2 with 4 insects per plant the treated plant shows the reduction of height from 21.82 cm to 16.45 cm and the control sample shows an increase in height from 20.5 cm to 22.58 cm, similarly in Treatment -3, with 8 insects per plant the treated plant shows the reduction of height from 37.75 cm to 26 cm and the control sample shows an increase in height from 39.5 cm to 42.5 cm(Fig. 3& 6)

Root Length

Root length was measured and recorded, In Treatment -1 with two weevils per plant, the Root length was reduced from 12.43 cm to 11.12 cm (10.54 %) in the period of 90 days whereas the control sample shows an increase in growth of 17.75 cm to 18.37 cm (3.49 %) , In the Treatment -2 with 4 insects per plant the treated plant shows the reduction of Root Length from 11.93 cm to 10.75 cm and the control sample shows an increase in Root Length from 11.75 cm to 12.95 cm, similarly in Treatment -3, with 8 insects per plant the treated plant shows the reduction of Root Length from 13.26 cm to

11.10 cm and the control sample shows an increase in Root Length from 17.75 cm to 18.45 cm(Fig 4,5 &6).

Leaves / plant

Number of Leaves / plant initially was 6 to 8 and was reduced to 4 to 5 leaves / plant after a period of 90 days. In an experiment in Agram Tank in Bangalore (Jayanth, 1987) observed that No. of Leaves / plant was reduced from the initial value of 9.5 to 6.6 cm after a period of 18 month when observed in September, 1985.

Leaf length

The length of the healthy leaf was measured and recorded. When in Treatment -1 with two weevils per plant The plant leaf length was reduced from 11.43 cm to 10.30 cm (9.79 %) from the initial value however when compared with control sample shows an increase in growth of from 15.0 cm to 15.67 cm (4.46 %.) In the Treatment -2 with 4 insects per plant, the treated plant shows the reduction of leaf Length from 10.50 cm to 10.20 cm and the control sample shows an increase in leaf Length from 10.40 cm to 12.0 cm, similarly in Treatment -3, with 8 insects per plant the treated plant shows the reduction of leaf Length from 15.0 cm to 13.50 cm and the control sample shows a increase in leaf Length from 15.0 cm to 17.50 cm(Fig.5&8)

The reduction of leaf length was also reported in the experiment in Kenya Lake Vitoria Basin Kenya (Ochieletal., 2001) out of the four sites, two sites namely Suo Port shows the reduction of leaf length from 137.2 cm to 77.8 cm in 110 days and Bukoma beach shows the reduction of leaf length from 162.9 cm to 75.5 cm in 110 days and Kendu Pier shows an increase of leaf length from 19.9 cm to 31.3 cm in 112 days the other site namely Police Pear shows an increase in leaf length from 78.8 cm to 100.3 cm in 174 days.

Leaf width

The width of the healthy leaf was measured and recorded. In Treatment -1 with two weevils per plant the plant leaf width was reduced from 12.07 cm to 11.13 cm (7.46 %) from the initial value however when compared with control sample shows an increase in growth from 14.25 cm to 15.16 cm (5.61 %). In the Treatment -2 with 4 insects per plant the treated plant shows the reduction of leaf width from 10.65 cm to 9.95 cm and the control sample shows an increase in leaf width from 10.40 cm to 12.40 cm, similarly in Treatment -4, with 8 insects per plant the treated plant shows the reduction of leaf width from 14.0 cm to 12.75 cm and the control sample shows an increase in leaf width from 14.25 cm to 14.79 cm (Fig.9). In the experiment in Kenya Lake Victoria Basin Kenya (Ochieletal., 2001) while leaf laminar area ranged from 50.6±4.4 to 109.8±9.6 cm2, Mean number of adult weevils was low, ranging from 0.1±0.1 to 0.6±0.2, The reduction of leaf laminar area was also reported out of the four sites, three sites namely Suo Port shows the reduction of leaf laminar area from 195.4 cm2 to 110.2 cm^2 in 110 days and Bukoma beach shows the reduction of leaf laminar area from 178.6 cm^2 to 126.8 cm^2 in 110 days and Kendu Pier shows reduction of leaf laminar area from 146.8 cm^2 to 124.8 cm^2 in 112 days the other site namely Police Pear shows an increase in leaf laminar area from 49.0 cm^2 to 74.6 cm2 in 174 days.

Feeding scars

The feeding scars were counted and recorded in table 4 based on visual observations. The number of healthy leaves per plant was also counted and recorded based on visual observation. The presence of weevils indicates there will not be any healthy leaves. All the fresh leaves are fed by the weevils.

Table 4 Feeding scars on *Eichorniacrassipes*

	3 days	6 days	9 days	12 days
Treatment-1	18	35	47	54
Treatment-2	21	38	49	62
Treatment-3	29	42	51	65

The results indicate that the feeding scar increases with the number of weevils released. In an experiment in Mexico (Martínezjiménez *et al*. 2001) at two sites where bio-control was established 90% of all leaves shows numerous feeding scars after four years.

when compared to the experiment in Kenya Lake Vitoria Basin Kenya (Ochiel*et al*., 2001) , in all the four sites namely, Suo Port 98 scars in 111 days, Bukoma beach 105 scars in 110 days, Police Pear 119 scars in 174 days and Kendu Pier 260 scars observed in 112 days.

Resprouts of E.crassipes plants

The resprouts potential of *E.crassipes* plants were assessed by computing the proportion of the total surface area of the pot to the area covered by fresh growth of *E.crassipes* plants. In all the treatments there was no new ramets production which is comparable to the experiment in Kenya Lake Vitoria Basin Kenya (Ochiel *et al*., 2001) Post-release sampling data collected between October 2000 and December 2000 indicated that average number of rametes ranged from 1.4± 0.2 to 3.3±0.4.

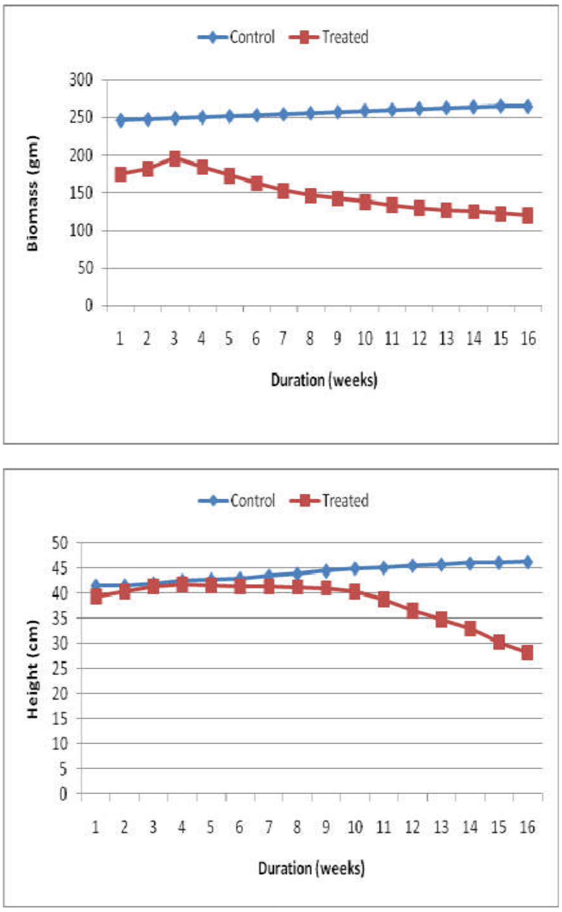


Fig 3 Effect of weevil on *E.crassipes* Biomass &Plant Height (2weevils/plant)

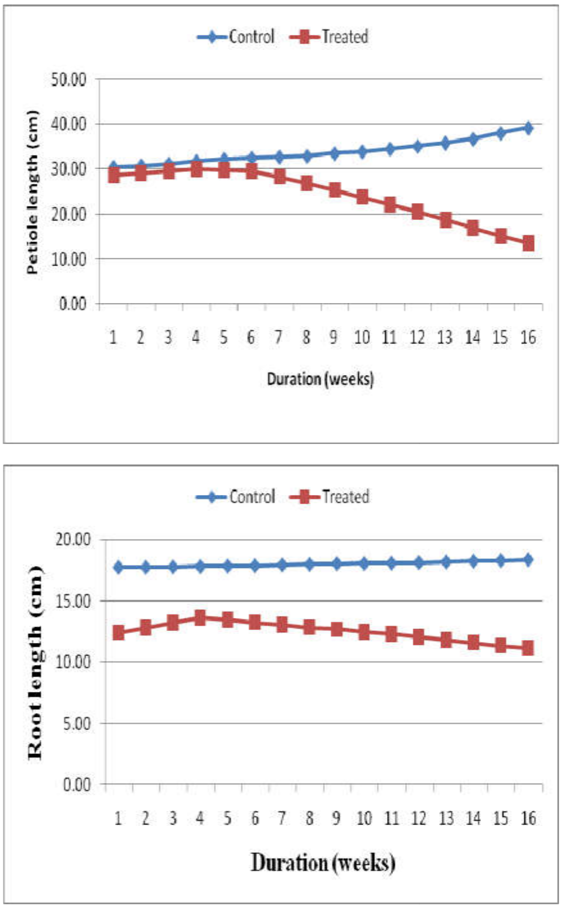


Fig 4 Effect of weevils onE.crassipes Petiole Length & Root length (2 weevils/plant)

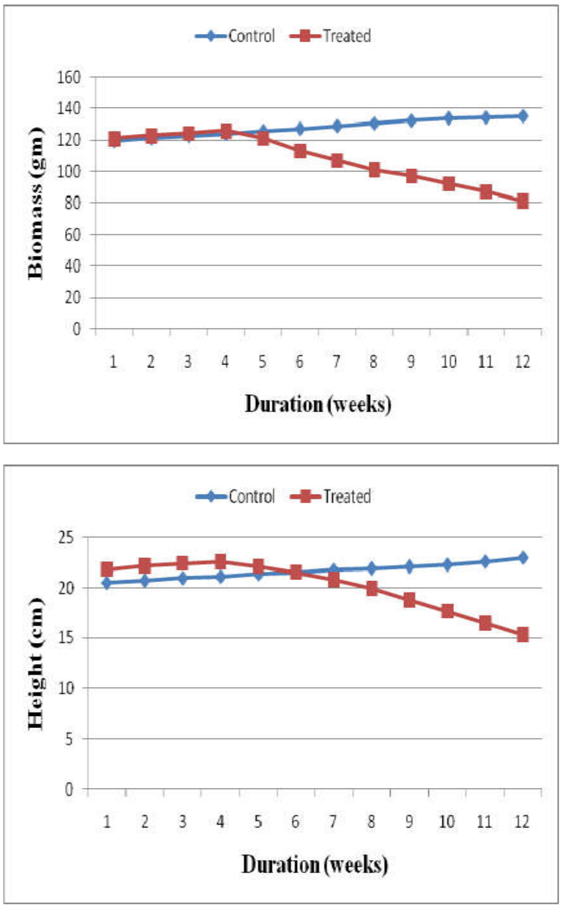


Fig 6 Effect of weevils on*E.crassipes* Biomass&Height (4 weevils/plant)

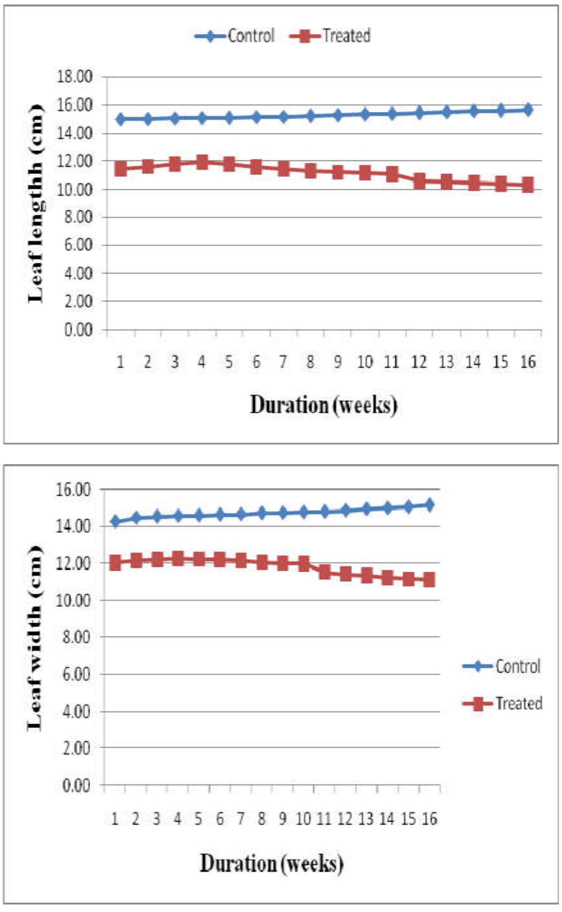


Fig 5 Effect of weevils on*E.crassipes*- Leaf Length & Leaf Width (2 weevils/plant)

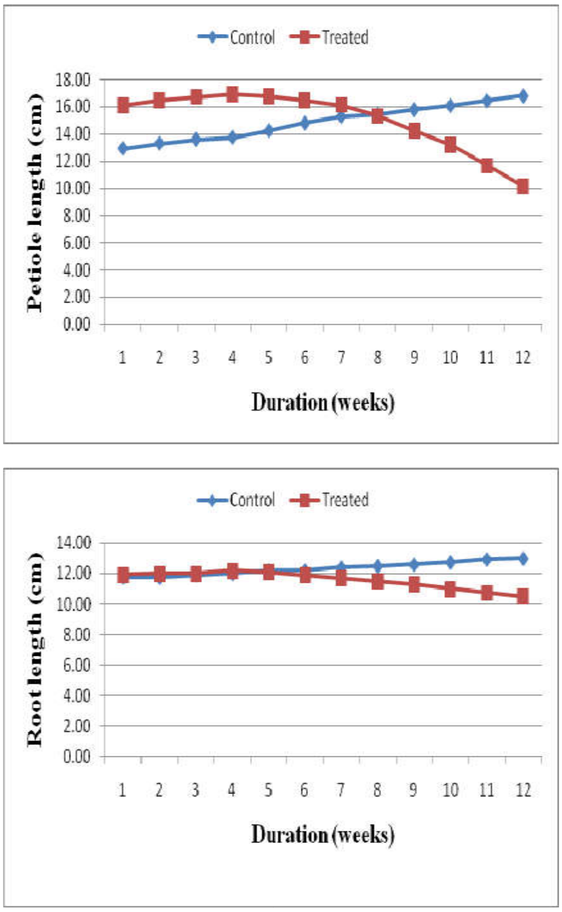
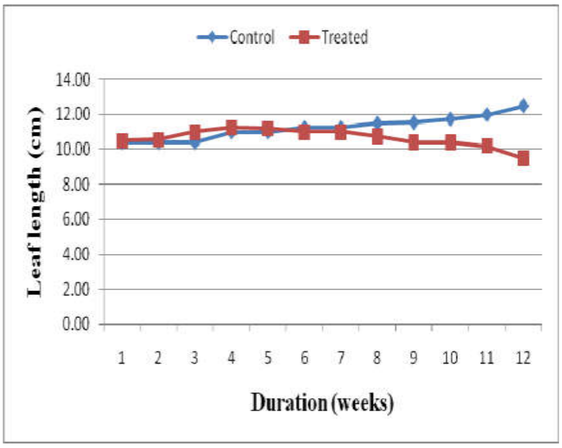


Fig 7 Effect of weevils on *E.crassipes* Petiole length&Root length (4 weevils/plant)



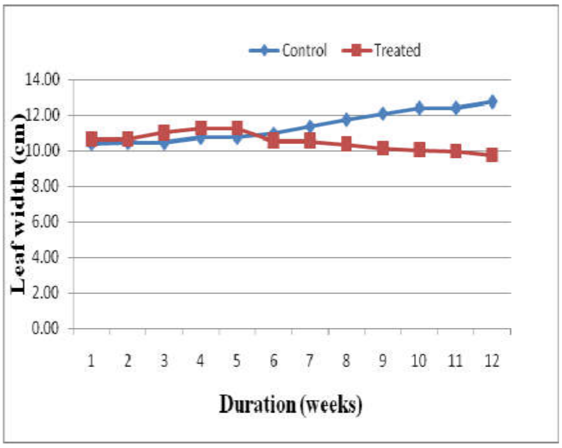
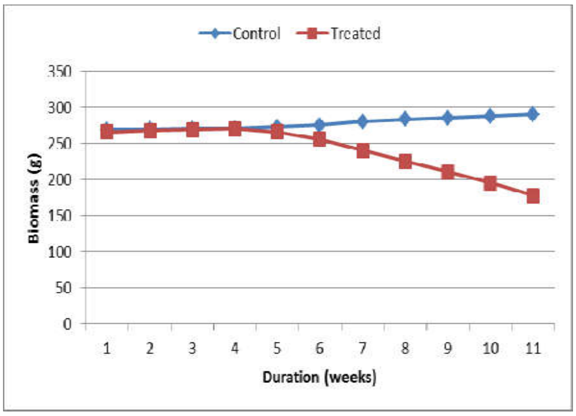
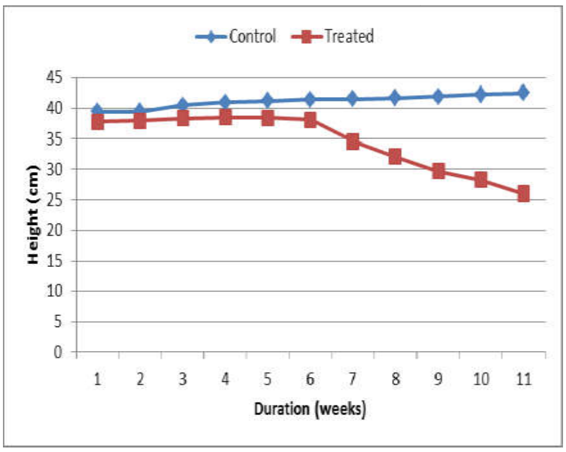
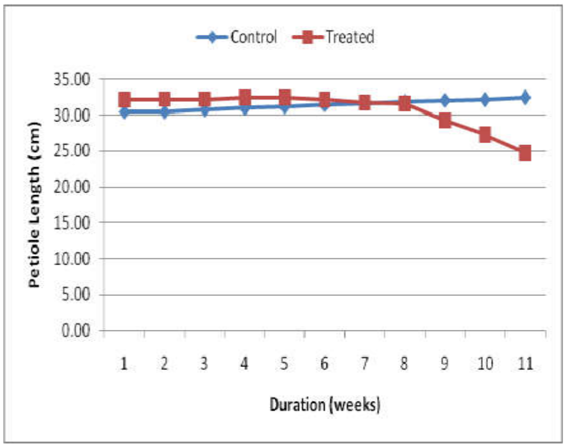
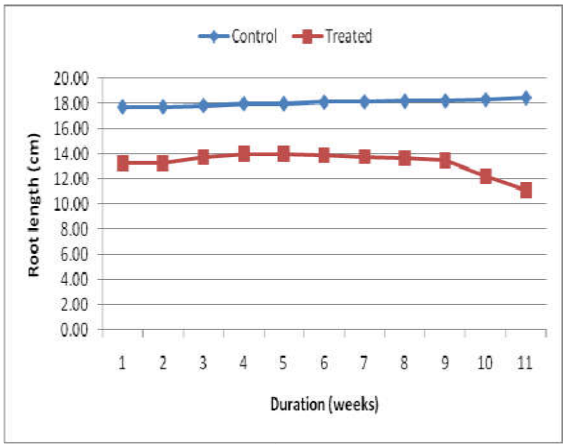


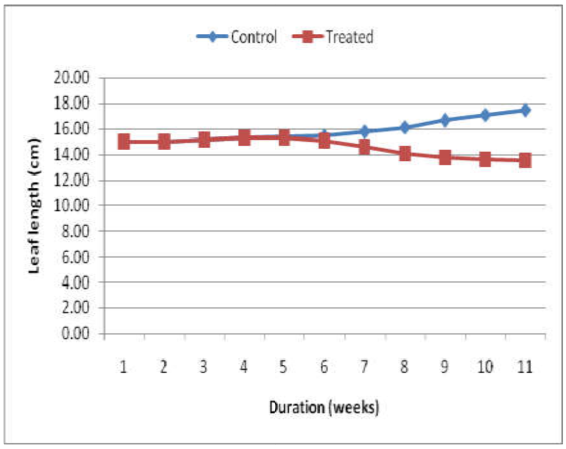
Fig 8 Effect of weevils on *E.crassipes* Leaf length &Leaf width (4 weevils/plant)











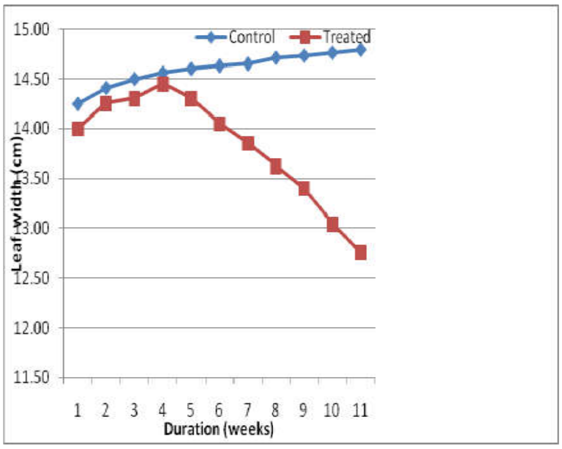


Fig 9 Effect of weevils on*Eichorniacrassipes* (8 weevis/plant)

Analysis of data

The effectiveness of the treatment was statistically analysed by conducting a paired "t" test for all the growth parameters and for all treatments.The control sample and treated sample were compared.

The formula used is t = (D – 0) / S_D/SQRT.(n)
Where "D" Mean of the difference
S_D – StandardDeviation of the difference
n – number of samples
Null hypothesis : $\mu_D = 0$
Alternate hypothesis : $\mu_D > 0$
Level of Significance: $\alpha = 0.05$
From the paired "t-test" it is concluded that 2 weevils per plant is most effective in controlling the growth parameters of water hyacinth weed.

Optimizing the weevil release in the Tank or Pond

A quadrat of 0.5 M x 0.5 M was selected, an average of 1.5 plants was observed in dense condition of water hyacinth.
For one square metre of weed coverage 6 plants and 12 weevils are needed.

For a tank of one hectare with 50% coverage of weeds a total of 3000 weevils are needed.

SUMMARY AND CONCLUSIONS

Results of the laboratory studies show that the *N.eichorniae* and *N.bruchi* are very good biocontrol agents. The adult weevils feed on the leaves and as the feeding scars increase the leaves are discoloured and curling occurs. The larvae of the *N.eichorniae* and *N.bruchi* tunnel into the petiole and cause damage to the internal tissue and this causes the decay of the leaves. The number of leaves per plant is gradually reduced. The weevils usually prefer the scarp the tender leaves. While doing so they retard the growth at the terminal portion of the plant. The inflorescence is therefore reduced after the introduction of the bio-control agents. The weevils suppress the reproduction of water hyacinth plants. As decay occurs gradually the microbes present in the water body decompose the debris. No adverse effects are felt on the waterborne communities. Density reduction, feeding scar are also other parameters are the other parameters which show the weevil performance.

It is not possible to generalise about the level of weevil populations required to control hyacinth as the relationship between insect populations and the damage that leads to control will vary with each site and the local environment. Counts of weevils and feeding scars are instead indicators of the presence of and changes to population numbers over time. However, 2 weevils treatment is most effective when compared with other treatments of 4 insects per plant and 8 insects per plant.

An average of 3000 weevils is needed to biologically control the aquatic weed water hyacinth of one hectare water spread area of Tank.

The present study results obtained indicates that *N.eichorniae* and *N.bruchi* are capable of bringing about the biological control of water hyacinth thereby opening up water bodies for economic uses like fishing, irrigation, navigation, etc., Distribution to other parts of the country holds out promise of control of this noxious weed. During the period, the plants were not as prolific as during the peak infestation period and a considerable decline in biomass was experienced. Leaf petiole length and laminar area, classified as low to medium was due to suppressed growth of hyacinth plants. Despite thelow weevil populations, there was a high population of immature stages (larvae and pupae). The adult weevil populations were expected to steadily increase with time.

Various strategies can be followed towards the management of water hyacinth, but the success in implementing the particular method relies on the economic and environmental feasibility. The only sustainable method for water hyacinth management is biological control.

Small infestations of water hyacinth will continue to harbor populations of the bio-control agents so that if regrowth of weed occurs the control agents can build up rapidly to restore control. Once established, the process should be largely self-perpetuating and self-regulating. The present study emphasizes the interactions of the weevils with the water hyacinth and the findings therefore pertain to management of water hyacinth with the weevils.

References

Bennett F.D (1984) "Biological control of aquatic weeds. "*Proc. Int. Conf. Water hyacinth*. Thyagarajan, G. ed. UNEP Res. & Proc. Series 7. Nairobi, pp14-40.

Center T. D, K.K.Steward and C.M.Bruner(1982) "Control of water hyacinth (*Eichhorniacrassipes*) with *Neochetinaeichhorniae* (Coleoptera: Curculionidae) and a growth retardant."*Weed Sci.* 30: 453-457.

CharudattanR(1996)"Pathogens for biological control of water hyacinth."*In*Charudattan, R., Labrada, R., Center, T.D. and C. Kelly-Begazo, eds."*Strategies for water hyacinth control"*. Report of a Panel of Experts Meeting, 11-14 September, 1995. Fort Lauderdale, Florida USA. FAO, Rome, pp. 90-97.

CofrancescoA.F (1985)M. Steward, & D.R.Sanders, , The impact of *Neochetinaeichhorniae* (Coleoptera: Curculionidae) on water hyacinth in Louisiana. *Proc. VI^th Int.Symp. Biol. Contr. Weeds*. Vancouver, Canada. ed. Delfosse, E. E. *Agric. Can*. pp. 525-535.

Deloach C. J, and H.A. Cordo (1983) "Control of water hyacinth by Neochetinabruchi (Coleoptera: Curculionidae: Bagoini) in Argentina." *Environmental Entomology*. 12. pp 19-23.

Galbraith J. C(1987) "The pathogenicity of an Australian isolate of *Acremoniumzonatum* to water hyacinth, and its relationship with the biological control agent *Neochetinaeichhorniae*." *Aust. J. Agri. Res*. 9 (29): 19-229.

HarleyK.L.S(1990)"The role of bio-control control in the management of water hyacinth, *Eichhorniacrassipes*. "*Bio-control News and Information* 11(1): pp11-22.

Jayanth K. P (1987) "Biological Control of Water Hyacinth (*Eichorniacrassipes*) in India by the release of the exotic weevil *Neochetinabruchi*, Curr. Sci. 57: 968 – 970.

Jayanth K. P (1988) "Biological Control of Water Hyacinth in India", *Technical Bulletin No*.3, Indian Institute of Horticultural Research, Bangalore, India, pp 28.

Jayanth K. P, and S.Nagarkatt (1987) "Host specificity of *Neochetinabruchi*Hustache (Coleoptera: Curculinidae) introduced into India for biological control of water hyacinth." Paper presented at National seminar on Biological control, Gujarat Agricultural University, Anand, 29th June to 2nd July 1987.

Marlin Danica A, P Hill Martin, P. Ripley Brad, G. Strauss Abraham, J.ByrneMarcus(2013) "The effect of herbivory by mite *O.terebrantis* on the growth and photosynthetic performance of water hyacinth (Eichorniacrassipes) j. Aquatic Botany, January 104, pp 60-69.

Martínez Jiménez M, and R.Charudattan(1998) "Survey and evaluation of Mexican native fungi for potential biocontrol of water hyacinth."*J. Aquat. Plant Management.* 36: pp145-148.

Monsanto (1996)"An Integrated Control and Management of Water Hyacinth"

Ochiel G.S, S.W. Njoka, A.M Mailu and W. Gitonga(2001) "Establishment of Spread and Impact of Neochetina spp. On Water hyacinth in Lake Victoria, Kenya – Biological and Integrated Control of Water Hyacinth (*Eichorniacrassipes*), edited by M.H. Julien, M.P. Hill, T.D. Center and Ding Janqung – *ACIAR Proceedings*, P. 102.

Perkins B. D (1978) "Enhancement of effect of *Neochetinaeichhorniae* for biological control of water hyacinth."*Proc. 4th Int. Conf. Biol. Control of weeds*. Gainesville, Florida.(ed. Freeman, T.E. pp 87-92.

RaoV.P (1969) Possibilities of biological control of aquatic weeds in India. *Water Resources J*. Sept. 1969 pp. 40-50.

Terry P. J (1991) "Water hyacinth in the lower shire, Malawi and Recommendations for its ControlLong Ashton, UK" , AFRC *Inst. of Arable Crops*. Res., p. 64.

Villamagna A(2009) "Ecological Effects of Water hyacinth(*Eichorniacrassipes*) on lake Chapla, Mexico" Dissertation submitted to the Faculty of Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Wright A.D and T.D. Center (1984) "Predicting population intensity of adult *Neochetnaeichornia* from incidence of feeding on leaves of water hyacinth" *Environ. Entomol.* 13: pp1478-1482.

How to cite this article:

John D and MerlineSheela A (2018) 'Control of Water Hyacinth (Eichorniacrassipes) Using Weevil ', *International Journal of Current Advanced Research,* 07(1), pp. 9013-9020. DOI: http://dx.doi.org/10.24327/ijcar.2018.9020.1474

****