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POTENTIAL OF *ZYGOGRAMMA BICOLORATA AS* BIOCONTROL AGENT FOR THE MANAGEMENT OF *PARTHENIUM HYSTEROPHORUS* TO SAVE ENVIRONMENT, HEALTH AND BIODIVERSITY IN NAGPUR

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ABSTRACT
Parthenium hysterophorus L., commonly known as carrot weed or congress grass in India has been considered as one of the most invasive weed. It is responsible for causing health problems to human beings and also to farm animals, besides causing loss to crop productivity and plant biodiversity. The weed has infested million hectares of land in India since it was first noticed in the year 1955. Now it is one of the major weeds in all types of agricultural lands in India along with infesting nearby wastelands, community lands, roads and forests.
In an attempt towards biological control of *Parthenium hysterophorus* L we found that the Mexican beetle *Zygogramma bicolorata* to be an effective biological control agent for *Parthenium hysterophorus* in India as it feeds primarily on this weed. The eggs, larval and adult stages of the beetle were collected from the field. Mass rearing of the beetles was undertaken in laboratory condition. After the successful multiplication of the life cycle, the beetles were released in a field invaded by *Parthenium* and monitored for three consecutive years to chart the effect of these beetles on *Parthenium* and their performance in consecutive years. The abundance of *Parthenium* in the infested area declined after three months of release of *Z. bicolorata*. At the beginning of second year it was noticed that the adult Mexican beetles emerged out from the soil indicated that the insect had successfully acclimatized to the region. This paper aims at helping the people affected by this exotic weed *Parthenium hysterophorus* and to make strategy for the control using ecofriendly approach.
Keywords: Biological control, *Parthenium hysterophorus, Zygogramma bicolorata*

INTRODUCTION

Parthenium weed (*Parthenium hysterophorus* L.) is an annual herb of Asteraceae family, originating from tropical Americas and now considered a weed of global significance (Dhileepan, 2009). It is a weed that not only reduces crop yield, but also causes health hazards to humans and livestock besides narrowing biodiversity. It reduces crop and pasture productivity, along with reducing the native plant biodiversity and negatively affects human and animal health (Nath, 1981; McFadyen 1995; Shabbir & Bajwa 2006). In India, it was first noticed in Pune (Maharashtra) during 1955 as a stray plant near garbage dumps. But in a short period, it spread all around Pune; covering wastelands, railway yards, marshy patches, fallow cultivable lands, grasslands, roadsides, along the canals and any area that was suitable for it.

Parthenium is controlled in most areas of the world is by chemical, physical or by biological methods. The use of chemical herbicides is extremely low partly because of its high cost and also on its effect on perennial grasslands. For individual *Parthenium* weeds just like common weeds for certain crops, control can be achieved by using 2,4-D or residual herbicides such as atrazine (Holman 1981). Control can be achieved by maintaining good grass growth to maximize competition against the weed; this can be achieved by lowering stocking rates (Holman 1981). Compared to Chemical control, Biological control is feasible and the search for natural control agents is going on in Australia and India.

A leaf defoliating beetle, *Zygogramma bicolorata* Pallister (Chrysomelidae: Coleoptera), was first found in forest reserves of central India. The *Z. bicolorata* had been tested and released as a classical biological control agent in 1980 in Queensland, Australia, where this biological control agent had a significant effect on Parthenium weed (Dhileepan, 2001/2003). The beetle was independently tested and released as a biological control agent against Parthenium weed in India in 1984 (Jayanth, 1987). To date, there is very little data on present distribution of *Z. bicolorata* in the core Parthenium weed infestations of central India. The main objective of this study was to record the current distribution of Parthenium weed and its biological control agent, *Z. bicolorata,* in central India to aid in future weed management planning.

MATERIALS AND METHODS

Systematic field surveys for Parthenium weed and *Z. bicolorata* were carried out throughout Nagpur region of central India during the period of 2013-2016. The survey was conducted on the major road networks which were infested due to its core infestation of Parthenium weed in cropped areas and Wastelands. The wastelands and cropped areas were also considered in the survey. The presence and absence of Parthenium weed and *Z. bicolorata* was recorded. If Parthenium weed was

present, its density per square meter, Plant height, shoot length, root length, stem diameter and plant biomass were also recorded.

After completion of the survey, an experiment was carried by using Mexican beetle (*Zygogramma bicolorata*) procured from Directorate of Weed Science Research (DWSR), Jabalpur (India). Beetles were reared in the plastic jars and fed daily on excised leaves of *Parthenium* weed at 27±2^{0}C Temperature and 65±5% Relative Humidity in Bio-techniques B.O.D. incubator. The wilted leaves were replaced daily with fresh ones. Newly hatched larvae were reared in petri-plates and when fully grown were transferred to plastic jars filled with moist sand, for pupation. Freshly emerged adults from the stock culture were isolated for use in experiments.

After the successful multiplication of the life cycle, the beetles were released in *Parthenium* invaded field. After every 15 days the density per square meter, Plant height, shoot length, root length, stem diameter and plant biomass were recorded. Plants biomass obtained by drying in an oven at 55^{0}C for 72 h and dry weight were recorded. For taking observations, 10 plants from each study area were randomly selected. The percentage reduction of *Parthenium* plant growth was calculated. On second and third year the same parameters were observes on same study area without release of *Z. bicolorata*. The number and performance of the beetles *Z. bicolorata* was monitored for the three consecutive years to check the effect of beetles on *Parthenium* and performance of the beetles year after year.

Statical analysis of the data was done using GraphPad online calculator. The values are represented as mean ± SEM. Students 't' test was applied to test the significance difference among the different groups.

RESULTS AND DISCUSSION

Severe, medium and mild infestation of *Parthenium* was recorded while negligible infestation of *Parthenium* was also recorded in some areas of Nagpur. Infestation of *Parthenium* was more prominent near the city and generally on the road commenced from the city. It might be due to disturbed natural habitat of native vegetation because of human disturbance like construction work, vehicular movements *etc*. This condition might have harbored and influenced the rapid spread of *Parthenium* in such habitat. Vehicular movements also facilitated the spread of *Parthenium*. The wide spread of *Parthenium* throughout India was reported by Sushilkumar (2012).

Till 1980, *Parthenium* spread was restricted mostly to uncultivated land, on road side and besides railway tracks and that time it was not considered a serious problem in India (Sushilkumar and Varshney 2007) but in a span of 30 years, the arid and hilly areas India have been infested with *Parthenium* and may become a serious problem to health of human beings, animals and agricultural fields. In the present study, the growth of *P. hysterophorus* was observed throughout the year in all the surveyed sites with greater abundance during the month of June to August. This might be due to congenial climatic conditions like high rainfall, optimum temperature and high relative humidity which favoured the growth of *Parthenium*. Till now, it was observed to be growing only along the sides of the roads, waste land and non-cropped area but if timely control measure are not taken, it may cause a serious threat to crop land and biodiversity.

Adults and grubs of *Z. bicolorata* damaged *Parthenium* and reduced plant height, shoot length, root length, stem diameter and plant biomass compared to control. The damage was more pronounced after 30 days of initial introduction compared to 15 days. The grubs fed more vigorously on leaves of *Parthenium* than the adults. However, the reduction in root length was not significant. 30 days of continuous feeding reduced 66.3% of plant height and caused 100% reduction in flower production. At the start of second year it was found that the adults of Mexican beetles were emerged out from the soil indicated that the insect was successfully acclimatized in Nagpur region. *Zygogramma bicolorata* was considered effective biocontrol agent for *Parthenium* suppression (Sangamitra and Monica Basu 2008). Sushilkumar (2010) discussed and reviewed the impact of bioagent *Z. bicolorata* in detail.

Table 1: Impact of biocontrol agent *Zygogramma bicolorata* on *Parthenium* after 30 days.

Criteria	Untreated	Treated	't' value
Plant height (cm)	17.5±1.51	9.42±1.20	4.17*
Shoot length (cm)	11.78±1.52	5.7±0.84	3.47*
Stem diameter (mm)	2.16±0.17	1.9±0.18	1.87^{NS}
Root length (cm)	1.53±0.25	4.12±1.10	2.29^{NS}
Plant biomass (mg/plant)	550.31±65.57	301.06±26.40	3.52*

Values are mean±SEM, n=10, NS- Not significant, * Significant

Table 2: Mean leaves defoliation (%) and leaf area loss (%) by *Zygogramma bicolorata* over three years (2012-2015)

Year	2012-13	201-14	2014-15
Defoliation (%)	90	40	33
Leaf area loss (%)	85	15	27

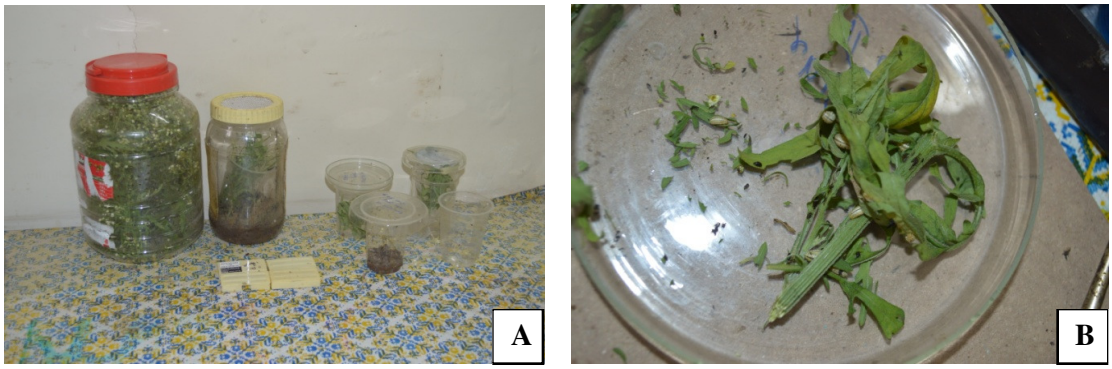

Figure. 1 (A-B): Rearing of beetles *Z. bicolorata* in laboratory

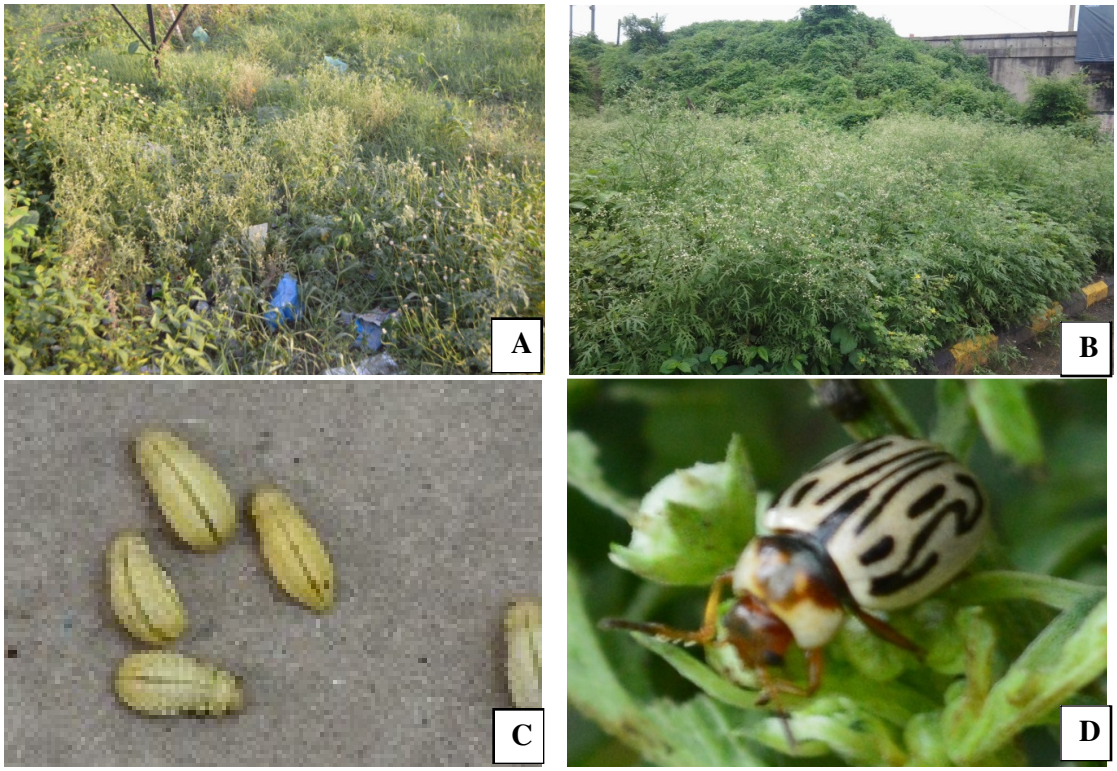

Figure. 2 (A-B) Parthenium infested area in Nagpur, **(C)** Final instar larvae of *Z. bicolorata,* **(D)** Adult of *Z. bicolorata*

The level of defoliation by *Z. bicolorata* varied significantly between years. In 2012-13, defoliation was evident in about 90% of plants resulting in maximum leaf area loss. In 2013-14 and 2015-16, defoliation was only evident in 40% and 33% of plants resulting in 15% and 27% leaf area loss respectively. Bio-control had a significant negative impact on Parthenium, but the impact varied between years. Bio-control was more effective on first year than second and third year, primarily due to defoliation by *Z. bicolorata*. Rainfall appears to be the major factor influencing the effectiveness of *Z.bicolorata*. In the following three years, due to below-average summer rainfall only low levels of defoliation were achieved. Summer rainfall also affected the incidence of *Z. bicolorata*.

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