

Advisory Note on *Parthenium* Management

Parthenium hysterophorus L., commonly known as carrot weed, white top or congress grass in India, is a herbaceous, erect and annual plant belonging to the family “Asteraceae” (compositae). It is most popularly known as “gajar ghas” due to its appearance like carrot plant. The origin of *Parthenium* is considered to be from Mexico, America, Trinidad and Argentina. After noticeable occurrence of *Parthenium* in Pune (Maharashtra) in 1956, it has spread like a wild fire throughout India. Initially *Parthenium* was a problem in waste and vacant land but now it has become a problematic weeds in crops also. In forest, it has become a serious problem in grasslands, particularly in national parks, on which herbivores-carnivores food chain survives. In general, about 35 million hectare land was estimated to be infested with *Parthenium* today. The increase of *Parthenium* infestation in crop area in recent past is alarming.



How *Parthenium* spreads?

It mainly spreads through its seeds. The weed has the potential of producing as high as 154,000 seeds/m² and a single plant can produce about 15000 - 25,000 seeds. The seeds are very light in weight and easily carried or transported by wind, water or through various human activities. *Parthenium* has the capacity to grow again from the cut or broken parts. Its allelopathic effects coupled with the absence of natural enemies like insects and diseases are two important factors responsible for its rapid spread in India.



Why *Parthenium* a dangerous weed?

In general, *Parthenium* is a poisonous, pernicious, problematic, allergic and aggressive weed posing a serious threat to human beings and their livestock. In India and Australia, this weed has been considered as one of the greatest source of dermatitis, asthma, nasal-dermal and naso-bronchial types of diseases. Besides ill effects, it also causes several other problems like

blockage of common pathways and reduces the aesthetic values of park, gardens and residential colonies.

Ways of management of Parthenium

Parthenium management success is based on integration of all the available techniques and their implementation throughout years given below:

1. Uprooting of *Parthenium*

It is one of the most effective methods to reduce the seed bank in future. Uprooting should be done during rainy season or in wet soil. Utmost importance should be given to uproot the plants before flowering. Uprooting will not be useful, if done after flowering. During summer and winter, it is hard to uproot the plant and if tried, plants are broken, from which further regeneration take place. done. During rainy season, in villages and municipality areas, labour may be employed under MGNREGA and cleaning scheme, respectively.

It is known that about 4% population is sensitive to *Parthenium*. If any symptoms are reflected about itching, swelling of skin etc. such persons should not be employed for *Parthenium* uprooting programme. Persons/labours should be provided hand gloves during uprooting programmes and should be advised to wear full sleeve shirts to avoid direct skin contact with the weed.

2. Mechanical management

In many crop fields *Parthenium* germinate profusely when left as fallow for one season. In such situation, mechanical deep ploughing before flowering is good and economical. The weed will be turned as green manure. Precaution should be taken to give spot chemical treatment over those plants which remain on surface as such plants not buried completely may rejuvenate.

3. Cultural management

Farmer should be advised to take fast growing crop like sorghum, and *Sesbania* (daincha) to suppress the growth of *Parthenium* in their crop field, particularly when fields are supposed to kept as fallow.

4. Legal management

State and Central government should declare *Parthenium* as Noxious weed and implement law to held responsible the owner of a vacant field/land/plot. Municipalities in town/cities, transport ministry on road side, railway ministry on railway tracks side; irrigation departments on the bunds of irrigation canals should take appropriate step to control the weed by available methods.

5. By use of chemicals

At some places and areas where, *Parthenium* can not be managed by uprooting due to lack of labours and high cost, *Parthenium* can be controlled by use of glyphosate (1 to 1.5%) for total vegetation control and by metribuzin (0.3 to 0.5%) or 2,4-D (2-2.5 kg a.i), if grasses are to be saved.



In different crops, the use of herbicides should be done only after consulting weed scientists because for different crops, different herbicides are required. Alaclor (2.0 kg a.i) can be used as pre-emergence to control *Parthenium* in soybean, rajmaha, banana and tomato crop. Metribuzin (0.50 to 0.75 kg) can be used as pre-emergence just after sowing to control *Parthenium* in potato, tomato and soybean crop. Atrazin can be used in maize to control parthenium.



By use of biological control agent

Biological control is the intentional manipulation of natural enemies by man for the purpose of controlling harmful weeds. Biological control is inexpensive and poses no threat to non-target organisms, environment and biodiversity. There may be different types of biocontrol agents like insects, fungi, nematodes, snails, slugs and competitive plants. Insects have received maximum attention in biological control of *Parthenium* followed by competitive plants and pathogens. It is self-perpetuating and can spread on its own while other control measures require inputs periodically. It is easy to integrate with other control measures. So far, biological control

using *Zygogramma bicolorata* has emerged one of the most promising methods. Under the biological control programme, host-specific bioagents from the native home of the weed are imported into other countries, where the weed had entered and became invasive. Therefore, it has been described in more details.

Introduction of Mexican beetle *Zygogramma bicolorata* in India

In India, more than 50 insect species have been reported on *Parthenium*, but none of the indigenous insects was found host-specific yet. Based on well documented success by Mexican beetle, *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae), in other countries where they were introduced, beetle were imported from Mexico to India. After in-depth laboratory and field studies, it was found host specific, which can eat only *Parthenium*, hence, its' use was permitted by Government of India. Therefore, Mexican beetles can be multiplied and released anywhere in India for *Parthenium* suppression.

Biology of Mexican beetle: Both the grubs and adults of *Z. bicolorata* feed on *Parthenium* leaves. Beetles are off white or light reddish in colour with dark brown longitudinal markings on the elytra, measuring about 6 mm in length. Light yellow eggs are laid generally on ventral



side of the leaves and hatch in 4-7 days. There are four instars. The grubs feed for 10-15 days on the leaves and on maturity enter into soil and pupate below up to 15 cm depth. Beetles emerged after 8-12 days. The beetle completes



its life-cycle in 22-32 days. Insect completes 5-6 generations under field conditions. The female can lay up to 2500 eggs during its life span.

How beetles kill the *Parthenium* ?

Both adults and grubs are capable to feed on *Parthenium* leaves. Grubs after hatching, starts to feed on soft growing leaves which on maturity prefer mature leaves. Adults also feeds on leaves. On well establishment after its release in *Parthenium* infested area, it may cause large scale defoliation of *Parthenium*. Continuous defoliation of *Parthenium* brings reduction in seed bank and restoration of other vegetation.

In general *Z. bicolorata* remained most active during July to September except a few exceptions where beetle had caused appreciable damage on *Parthenium*, during February to April at some places in patches near the good moisture regime. At many places, all the stages of beetles may be recorded from the field in extreme winter and summer season near the high moisture regime.

The defoliation of *Parthenium* is of population dependant. Population build-up is also dependant on rains and temperature. After rains in June-July, population build-up starts but long dry spell can reduce the population build-up of the beetle drastically. Continuous or intermittent rains during June to September results high defoliation in large area by the end of August but dry spell of 15 to 20 days during June-July may result same defoliation by the end of September. Scanty rains or draught conditions during rainy season may cause severe setback in population build-up of beetle hence poor defoliation of *Parthenium*. Continuous attack of bioagent on the same site for 3-4 years results restoration of lost biodiversity.



Sequential photographs of the same site showing restoration of other vegetation due to attack of Mexican beetle.

Drastic reduction in flower production of second and third flush of *Parthenium* during rainy season is brought about by gregarious feeding by the early larval stages of the insect on the terminal and axillary buds. This feeding does not allow growth of the young plants and they are nipped in the bud



Young flush of *Parthenium* is nipped in the bud by the beetle.

Mexican beetle does not eat flower directly but in attempt of chewing soft tissues below the flower, it cut the flower from the pedicle hence contribute in destruction of flowers also. It was found that 5 beetles released in caged having flowered *Parthenium* plants, cut 25-37 (mean 31) flowers out of 115-137 (mean 119.8) within 10 days after their release. Thus one beetle directly cut a mean of 6.2 flowers within a 10 days and the life expectancy of adult beetle may vary from 30 to 150 days.



After continuous attack of beetle for 3-4 years, maximum seed bank is exhausted and other vegetation start to take the niche vacated by the *Parthenium*. But still, *Parthenium* germinates amidst other vegetation from the remaining seeds or seeds come from



out side. Mexican beetle defoliate these plants completely and thus further contribute in seed bank reduction.

Economic benefits of biological control by *Z. bicoorata*

In a conservative estimate, the beetle controlled 200-hectare land infested with *Parthenium* within three years of its release at Jabalpur. The cost of most effective herbicide metribuzin for one time application for 200 hectares accounted to be about Rs 5,40,000/- It is also to be noted that during rainy season, about 70-80% *Parthenium* germinates at different time after commencement of rains. Hence, at least two applications are required to control *Parthenium* which might have costed Rs 10,80,000/- in a season. By fourth year of release, beetle was estimated to control 900-hectare land that amounted to be worth of Rs 2.43 million of herbicide. If the same area has to be removed manually or mechanically, it will be about three times more of the herbicide cost. Therefore, it was concluded that biological control through *Z. bicolorata* has great potential at least in higher rainfall areas to manage *Parthenium*. The economic benefits will increase many-folds, if we take into consideration the indirect benefits derived in the form of environmental safety and increase in people health.

Collection and release of the beetle

(i) Collection from established sites: By virtue of release in different parts of India, Mexican beetles has established in many parts of India. Therefore, it can easily be collected from the established sites during July to September. For spotting its presence in the area, close observations during rainy season is required by turning the leaves. A new person while trying to collect the beetles from the infested plants, may experience that as soon as he tries to catch the beetle, it falls on the ground. Therefore, it is easy to collect the beetle by placing polythene or containers below the resting site of the beetle. A gentle jerk on twig will be enough to dislodge the beetle directly in to the polythene or container. Collection can be made in ordinary polythene bags or plastic containers that are perphorated with a needle for providing aeration. Upper twigs of plants without leaves should be placed inside the polythene to avoid the shrinking and to provide resting places for the insect.

(ii) Selection of release site: Care must be taken to make the initial releases in undisturbed areas, where manual and chemical control operations are not used. Initial release should be avoided in cultivated land because ploughing of land may disturb the pupation process hence poor survival and subsequent poor establishment. However, augmentative releases in the cultivable field can be made to enhance the population build-up of the beetle after initial establishment. Low lying areas prone to water logging should also be avoided because pupation takes place in soil. Attempts should be made to release the beetle on small and succulent growth of *Parthenium*. Beetle should never be released on flowering and large size *Parthenium* plants. If beetles are released at inappropriate site, breeding and population build-up will be slow, hence establishment of the bioagent will be delayed in such sites. Introductory releases in new area may be done involving people participation. This will help to make aware people about the bioagent.



(iii) Time of release: The ideal time for carrying out releases is after the commencement of the rains during rainy season. During that time plenty of succulent *Parthenium* plants are available in nature. There is no benefit in undertaking releases between November to May when they normally do not breed. However, beetles can be released in dry season also in those sites where

sufficient moisture allows the continuous germination of new *Parthenium*. Such sites may provide suitable microclimate for the beetle to multiply.

(iv) Method of field releases: Adults collected from the multiplication cages or the established sites can be released by just scattering the adults on *Parthenium* plants. It will be ideal to release full-grown grubs too. Since they enter the soil directly, the chances of their moving away can be avoided. When adults emerge they will feed and oviposit in the same area.

(v) Number of beetles to be released: Sufficient numbers should be released to increase chances of breeding and thereby ensuring establishment. One adult was found to bring about defoliation of a single *Parthenium* plant in 6-8 weeks. Therefore, if releases are to be carried out at this rate, about 0.4 to 0.7 million insects will be required per hectare, as in general the weed density varied between 40 to 70 plants per square meter. In practical, it is neither possible nor necessary to release so many insects as they are capable of multiplying rapidly. Releases of about 500-1000 beetles can bring about establishment and eventual control. Once plants are eaten up in the release spot, the insects migrate into adjacent areas. Taking this into consideration a number of release spots can be selected in a particular place or city, which can act as a focal point.

More releases mean quicker establishment of the beetle and therefore, better control. So, do as many releases as affordable during first couple of years of introduction and make additional releases in isolated areas in future. This method reduces the time for the beetle to build up the population and help the beetles to disperse fast. The least affordable approach is to introduce one or two releases into infested area and do nothing more. This method will get a colony started, but will be slow in terms of time and area.

What happens to the insects after the weeds are eaten? *Parthenium* will never be eradicated in a vast country like India due to its immense reproductive and survival capabilities. Some plants will always escape from the attack, which will allow the insect population to sustain itself during years of low weed density.

Can herbicides be used with beetle? Yes, herbicides can be used, but with care. Herbicides can be integrated as for most of the cases, herbicides may not kill the beetle population drastically but a few herbicides can kill the *Z. bicolorata* by direct hit. Therefore, only

recommended dose should be applied on first flush after initial rains. On observing good population of beetle on the infested site, chemical spray should be avoided.

How to do mass multiplication of the beetle?

For multiplying the beetle on small scale, we can use plastic jars/buckets, beakers *etc.* A bouquet of succulent *Parthenium* leaves with twigs should be made. To keep the leaves fresh at least for one week, the lower portion with twigs can be kept in wet cotton swab. In small containers we can keep a single pair of male and female while in large containers 3-4 pairs can be kept. Larvae will hatch in 2-3 days from the eggs and will start to feed on the leaves. After a week or on need, old leaves should be changed with fresh leaves. Small larvae should be transferred gently on the fresh leaves with the help of brush. After 12 to 18 days, larvae will be matured. At this time they need soil to pupate. Therefore, a few jars should be made exclusively for pupation purpose by filling wet soil in the containers/jars. The soil can be gently compacted. 4th stage larvae can be transferred in these pupal chambers wherein *Parthenium* leaves can also be kept as food. After maturity of 4th stage, larva will dig the soil and pupate. After 5-8 days, adult in the form of beetle will be emerged from the soil by making a circular hole. This method is cheap but cumbersome and requires continuous attention (Fig.10). From one such container, about 50-60 beetles can be obtained in a period of two months.

Mass rearing of *Z. bicolorata*

The most easiest and economic way to mass multiply the beetle is in mosquito cages. The cages may be made of different size as per need and space. *Parthenium* can be grown in these cages either from the seeds or by transplanting small *Parthenium* plants from the infested place. After establishment of sufficient *Parthenium* plants in the cages, about ten pairs of beetles can be released in the space of 6x 6 feet. Soon females will start to lay eggs and life cycle of the beetle will start inside the cages. Old and eaten *Parthenium* plants should be replaced regularly with the fresh plants as and when required. This method requires less



attention From one 2 x 2 feet space, about 400-800 beetles can be obtained in a period of two month. In a net house of about 10 x 20 m, 10,000 to 15000 beetles can be obtained within a period of two months.

Augmentative biological control of *Parthenium*

Augmentative liberations of bio-agents are generally undertaken when natural enemies are absent; occur too late or in numbers too small to provide effective pest control. It was observed that after inoculative release of *Zygogramma bicolorata* in an area, colony gets started but it takes about 3-4 years for good control of *Parthenium*. Even in the sites where beetle has already established, it takes time to make sufficient population build-up, which is capable to suppress the *Parthenium*. In nature, good control of *Parthenium* by the beetle is observed by the end of September. This delay in population build-up may be reduced by augmentation of mass reared beetles coincided with the monsoon and germination of first flush of *Parthenium* in early June. It has also been observed that population build-up of beetles in the released area vary place-to-place and year-to-year. In some places, good control of *Parthenium* is observed even in the July and early August and in that area large number of adults and grubs of the beetles are available and from this population, large fraction of beetle and grubs succumb to death after complete defoliation. If, this population is transferred to less active site, good population build-up may occur which may lead to early control in the augmentative area.

For example, if we find good pupalaion build-up of grubs at one site, terminal twigs of *Parthenium* of 30 cm length may be cut and collected in buckets. These may be scattered over other *Parthenium* stand where population of beetle



had not build-up yet. This inundative augmentation from the area of abundance to desire area will cause early population build-up in that area hence early control than the area where such augmentation is not made

Biological control by competitive plants

Keeping in view of various characteristics of plant species and their utility, *Cassia tora* and *C. serecia* have been recommended for competitive replacement of *Parthenium* in India. In non-cropped area, *Cassia tora* at the rate of 40-60 kg/ha should be broadcasted in the pre-marked *Parthenium* infested sites during March-April. The plants will grow during rainy season and would replace *Parthenium*. In the protected premises on the road side and bunds in crop field where *Parthenium* grows, marigold should be grown. Marigold will dominate over *Parthenium* besides to suppress nematode populations. By this approach, extra earning can be done by selling flowers besides beatification of premises.



Replacement of *Parthenium* by *Cassia tora* and marigold on road side

Management by way of utilization

Parthenium can be used for several purposes like antifeedant, anti-repellent and phagostimulant for insects; for preparation of biogas, paper and composite *etc.* But, all such use required skill and other essential equipments; therefore these methods cannot be used by unskilled common man. However, *Parthenium* can be most effectively used in compost making. The compost should only be prepared by pit method. In NADEP method (where compost is made over the ground in structure made of bricks) or open pit or heap methods, seeds of *Parthenium* are not killed. If such compost is used in crops, it will add thousands of seeds of *Parthenium*. To overcome the shortcomings of NADEP method, *Parthenium* compost should be prepared by pit method developed by Directorate of Weed Research. By this method, good quality compost devoid of *Parthenium* seeds is prepared. In this anaerobic method, seeds are completely killed due to rising of high temperature inside the pit.

A pit of 3 x 6 x 10 (depth x width x length) may be prepared in field where water does not stagnate. The length and width of the pit may be reduced or increased but depth cannot be compromised. The bottom surface of pit should be compacted. The *Parthenium* biomass should

be buried in the pit in layers. On each layer of 100 -150 kg, dung slurry (5 kg) or 200 to-500 gram urea should be sprinkled. Like this one layer, make several layers till the pits is completely filled up to one feet above of ground surface in dome shaped. After filling the pit, it should be closed by the mixture of soil and dung. After 2- 4 months, depending upon the maturity of plants, we may get 37-35% compost from the initial *Parthenium* biomass filled in the pit. The compost prepared by *Parthenium* contains more nutrients than the compost prepared by dung only.



Compost preparation by pit method

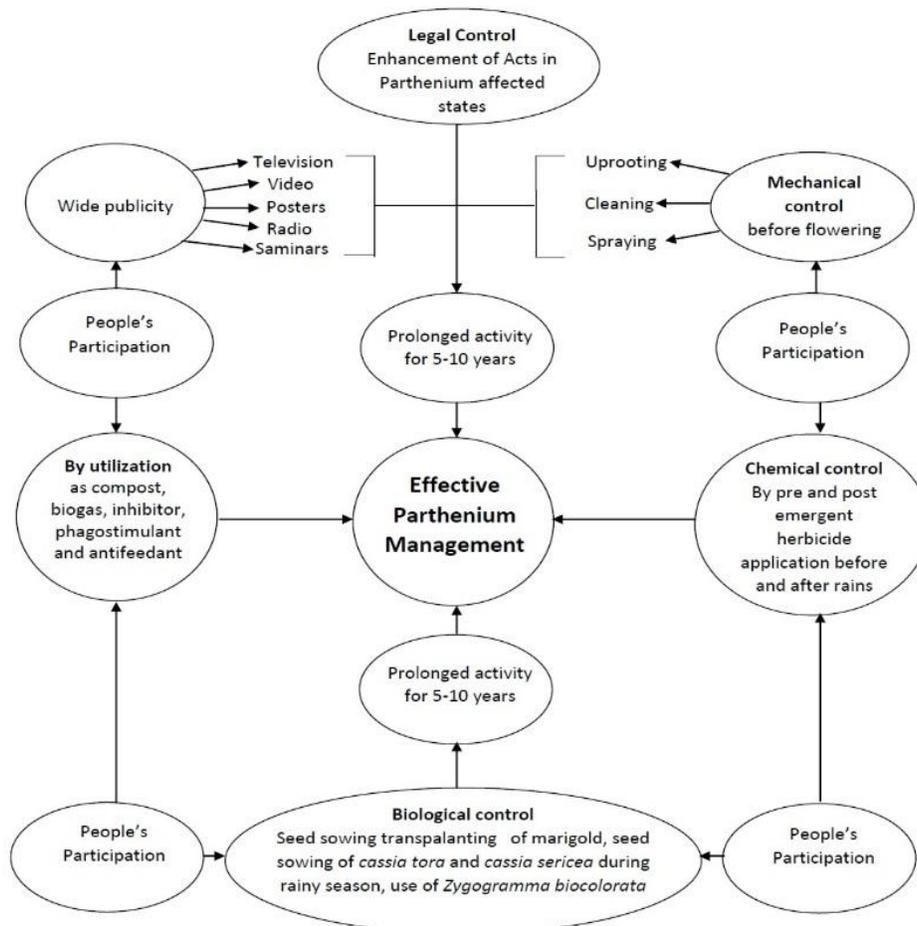
Integrated management

It has been established that *Parthenium* cannot be managed by any single methods due to its immense capacity to produce large number of tiny seeds throughout the year. Under this method, all the available techniques have to be integrated as per the requirement and available resources. However, as *Parthenium* is weed of wasteland, fallow land and vacant land, biological based integrated management will be the most suitable option.

During rainy season soil remains wet so manual or mechanical removal can be done before appearance of flowering with the help of people participation. During summer and winter, it is hard to uproot the plants but *Parthenium* density remains low in small patches, therefore use of spraying of glyphosate or metribuzin will be of much use to reduce the intensity of *Parthenium* in forthcoming season. Before monsoon, pre-emergent herbicide like atrazine, metribuzin @ 2.0 and 1.5 kg/ha can be applied, respectively on the sites already marked for dominant patches. This application will certainly reduce the intensity of the seed bank. On the onset of monsoon, spraying of glyphosate @ 1% solution or metribuzin @ 0.3% can control emerged seedlings of sufficient height, however, application should be made before flowering.

With the onset of monsoon, marigold seeds can be sown in the vacant soils of residential colonies, farm houses, office premises and any other protected areas on road sides or bunds. *Cassia sericea* or *C. tora* have been found very useful to suppress *Parthenium* in vacant land. The best way is to collect the seeds during October-November from the established site and should be scattered on the already marked dominated sites during March-April to enable to weaken the hard seed coat. The seeds will germinate during rainy season and will replace the *Parthenium*. The deliberate sowing of these plant species will be required only for initial 1-2 years, later they can perpetuate themselves.

Utilization of *Parthenium* in compost making, methane production, as phagostimulant, as antifeedant, and in other uses should also be encouraged. The scheme is given below



People awareness and capacity building programme

For successful *Parthenium* management at national level, people participation and awareness are imperative. Therefore, each participating unit should organize *Parthenium* Awareness day, week, fortnight or months. Live demonstration, uprooting involving people, students and employee, demonstration, photo exhibition, video showing, rallies etc. should be done during awareness programmes. Media should always be invited while doing such activities to make people aware about the weed.

The training of different stakeholders is also very important step for successful implementation of *Parthenium* management. Training to master's trainers representing different stakeholders from different states may be provided by Directorate of Weed Research, Jabalpur. These master trainers may further train and disseminate the knowledge among other stakeholders. Emphasis has to be given to spread the message of programmes through electronic and print media.

The initial culture of bioagent *Z. bicolorata* may also be provided by the Directorate of Weed research for further mass multiplication and dissemination besides giving training to stakeholders.
