# Introduction of *Parthenium hysterophorus* L: Status and Management

**M Mahadevappa[1] and RD Gautam[2]***

[1] *Advisor, Sri Shivarathrishvara Rural Development Foundation, Mysore-570004, Ex-Chairman, Agricultural Scientist Recruitment Board, New Delhi-110012, India*

[2] *Division of Entomology, Indian Agricultural Research Institute, New Delhi-110012, India*

*Parthenium hysterophorus* is now a serious weed of pastures, wastelands and also of agricultural fields growing under varied environmental conditions, from sea level to altitudes up to 2000 masl, in most parts of India. Concerted efforts including physical, mechanical, chemical and biological methods of its control together have to be made at least for initial 2 to 3 years for its effective suppression in the marked area. Individuals should render responsibility to eliminate the *Parthenium* plants establishing in their surrounding. Establishment of the effective botanical agents like exotic shrub *Cassia sericea* and other indigenous plants *viz., C. tora, C. auriculata, C. occidentalis, Tephrosia purpurea* and *Kochea indica* (suitable for arid region) is a viable strategy along with the release of leaf feeding Mexican beetle, *Zygogramma bicolorata.* Further, foreign exploration of safe and effective weed killer may be given a serious thought to compliment the potential of *Z. bicolorata,* in the light of recently introduced International Standards for Phytosanitary Measures (ISPM#3). Community based approaches consisting of activity classes for school children, NGO's and others will help in weed containment. Bringing short-term legislation/notification similar to that of mosquito especially in the metropolitan cities may be an added weapon in integrated parthenium management. Appropriate integration of these approaches could contain the spread of *P. hysterophorus* and provide sustainable suppression especially in non-cropped ecosystem. This may lead to direct protection of environment.

**Key words: *Parthenium hysterophorus, Zygogramma bicolorata, Cassia sericea, Kochea indica,* Legislation, Management**

The pernicious weed, *Parthenium hysterophorus* L, commonly known as congress grass, carrot weed, white top, star weed or fever few etc, growing naturally since centuries in Latin America and many other countries has emerged as one of the seven most dreaded weeds of the world. In India, it was noticed for the first time from Pune (Rao, 1956). It is presumed that it could have introduced as contaminant along with wheat consignments. According to Krishnamurthy *et al.* (1977) about 2 m ha of land is covered by this weed in the country, with a potential of dramatic increase. The distribution of this abnoxious weed is mostly on no-man's land like abandoned and wastelands, vacant sites, roadsides, railway tracks, graveyards, backyards, cultivated lands etc. (Mamatha and Mahadevappa, 1992).

Due to the rapid and gregarious growth of parthenium, the ill effects on human, livestock (Narsimhan *et al.*, 1980; Towers and Rao, 1992) and plants, have been well published and demonstrated to create public awareness. Besides, the weed has posed wide interference in agriculture (Vartak, 1968; Kanchan and Jayachandra, 1975). Its distribution, chemistry, hazards, competitive plants and management have been extensively reviewed (Krishnamurthy *et al.*, 1977; Towers *et al.*, 1977; Parihar and Kanodia, 1986; Joshi, 1991; Agarkar, 1999; Mahadevappa, 1999; Sharma and Gautam, 2004). Sometimes, in chronic parthenium linked photo-dermatitis patients, situation may be incurable and fatal.

## Special Features of the Weed

All the plant parts, particularly pollens have allergic effects on other organisms. The life cycle of the weed is of short duration. It can germinate, flower and set seeds within four weeks. A single plant alone can produce 14-15 thousand seeds. Once established, it can survive severe droughts and frosts (Mahadevappa, 1999). Further, factors such as (1) the absence of potential natural agents that restrict the spread of this plant as in its original home, (2) high fecundity, (3) efficient seed dispersal mechanisms, (4) monopolistic allelopathic impact on most other plant species, (5) unsuitability for grazing because of the presence of antifeedant in the plant system and (6) wide adaptability to varying soil and agroclimatic conditions have enabled this plant to invade a variety of growing environments particularly in situations associated with human activities (Mahadevappa,1999; Sharma and Gautam, 2004).

## Weed Utility Aspects

*Parthenium* has been regarded as a beneficial plant too. It is used as a folk remedy against various afflictions such as ulcerated sores, skin diseases, facial neuralgia,

* *E-mail: gautamjul@yahoo.com*

for cleaning the blood and also as an insecticide. It is reported that "parthenin", the principal ingredient of this plant possesses anticancer properties. *Parthenium* plants have been commonly used as centering material in the construction of buildings and bridges. Also, converting it into a resource by its multifarious uses like fuel for cooking, organic manure, biopesticides for plant protection (known to have insecticidal, bactericidal and herbicidal properties), making paper pulp for writing and corrugated sheets and as additive with cattle manure for higher methane production in biogas plant. However, there is a strong need to remember that parthenium linked problems to human, animal and plant health are yet to be investigated. Chemical constituents may remain viable source of health hazards even in parthenium-based product (s), in question, hence such products may be thoroughly examined before commercialization.

Possibility that *Parthenium* plants can be ensilaged after mixing it in certain proportion with conventionally used feed is also reported. The ensilaged *Parthenium* is reported to be devoid of the contact allergen/toxin and becomes palatable to live stock. The fibrous nature of the *Parthenium* stem is a point that needs the attention of industrial researchers to see if it has potential in manufacturing paper and such other materials as helmets, molded furniture, doors etc. In the years of drought when most plant species fail to grow, *Parthenium*, by virtue of its tolerance to drought, grows and brings down $CO_2$ level in the atmosphere. It is reported that 20 per cent *Parthenium* leaf water extract when sprinkled on mulberry leaves improved the quality as well as quantity of cocoon due to presence of steroids. As felt at present, its harmful effects both from medical as well animal health and agricultural production point of view are serious matters for consideration.

## Global Spread of *Parthenium*

Overseas spread of parthenium is reported from different countries (Table 1) and is spreading fast. Many countries have identified it as a pest of quarantine importance. A few observations based on literature search in India (Table 2) and authors own surveys carried out abroad are highlighted in Table 3.

## Reasons for its Wide Spread Dominance Across the Country

Several physiological and morphological features of the weed help in its large-scale dispersal and dominance in wide range of habitats.

- Prolific seeding potentiality (8000 – 15000 seeds per plant).
- Absence of seed dormancy (seen throughout the year).
- Absence of potential natural enemies.

**Table 1. Overseas spread of *Parthenium hysterophorus***

| Country | Provinces | References |
|---|---|---|
| Argentina | Large areas, Province of Cardoba | Castex *et al.* (1940) |
| Australia | Queensland, Central Highlands and Clermonth, New South Wales | Dale (1980) |
| Bangladesh | Not in alarming proportion | Mahadevappa (1996) |
| Bourbon | Large areas | Vaid & Naithani (1970) |
| Guyana | Large areas-major problem | Krishnamurthy *et al.* (1976) |
| Jamaica | Large areas-major problem | Krishnamurthy *et al.* (1976) |
| Mauritius | Large areas | Vaid and Naithani (1970), Maheshwari and Pandey (1973) |
| Mexico | Throughout the country | Arny (1897) |
| Nepal | Very sparse | Personal observation |
| North Vietnam | Large areas | Vaid & Naithani (1970) |
| Rodrigues | Large areas | Vaid & Naithani (1970) |
| Seychelles | Large areas | Vaid & Naithani (1970) |
| South Africa | Large areas | Vaid and Naithani (1970), Maheshwari and Pandey (1973) |
| Trinidad | Large areas-major problem | Krishnamurthy *et al.* (1976) |
| USA | Florida, Texas, North of Massachussetts, Pennsylvania, Ohio, Michigan, Illinois, Missouri and Kansas; Minnesota; Louisiana Cantan, Baltimore, Maryland, New Port and Virginia | Castex *et al.* (1940), Arny (1897) Mackoff and Dahl (1951) Ogden (1957), Arny (1897) |

**Table 2. Spread of *Parthenium hysterophorus* in India**

| State | Areas | References |
|---|---|---|
| Andhra Pradesh | Most parts of the state | Krishna Murthy *et al.* (1977)<br>Mahadevappa (1996) |
| Bihar | Motihari, Narkatiarganj, Balmikinagar,Gangetic plains | Maheshwari and Pandey, (1973)<br>Chandra (1973) |
| Delhi | Through out | Personal observations |
| Gujarat | Ahmedabad, Anand and Baroda | Mahadevappa (1996) |
| Haryana | Rohtak, Hisar and Faridabad, Eastern parts of Haryana | Mahadevappa and Ramaiah (1990) |
| Himachal Pradesh | Kulu and Manali | Vaid & Naithani (1970) |
| Jammu & Kashmir | Throughout the State | Prabhakar (1988) (Personal communication) |
| Karnataka | Most parts of the state except coastal belt and thick forests | Mahadevappa *et al.* (1990)<br>Jayachandra (1971)<br>Mahadevappa (1996) |
| Kerala | Palghat, Quilon, Kottayam and Kasargod | Mahadevappa (1996) |
| Madhya Pradesh | All over the state except in hills | Tiwari & Bisen (1984) |
| Maharashtra | Mumbai city (Juhu area), Forest nurseries, Joshi Estate | Tiwari & Bisen (1984)<br>Chandras and Vartak (1970) |
| Pondichery | Scattered distribution throughout the state | Mahadevappa (1996) |
| Punjab | Many parts of Punjab | Mahadevappa (1996) |
| Rajasthan | Udaipur | Mahadevappa (1996) |
| Tamil Nadu | Kotagiri of Nilgiri hills, Aliyar submergenic area, Coimbatore, Katpadi, Jolarpet, Madurai, Salem, Tanjore | Mahadevappa (1996) |
| Uttar Pradesh | Pantnagar, Rae Bareli, Jhansi, Haridwar | Mahadevappa (1996) |
| West Bengal | Calcutta, Bank and river basins | Krishna Murthy *et al.* (1977)<br>Mahadevappa (1996) |
| Orissa | Not much, only in the peripheral parts | Mahadevappa (1996) |

**Source:** Mahadevappa, 1999

**Table 3. Studies conducted on nature of invasion in a few countries**

| Country | Year of observation | Nature of invasion | Type of land where observed |
|---|---|---|---|
| Australia | 1986 | Low | Roadsides and abandoned land |
| Canada | 1987 | Very low | Abandoned land and road side |
| China | 1966, 2000 | Low | Roadsides and on land of rice |
| Cuba | 1987 | Low | Vegetable gardens, banana and maize fields |
| Ethiopia | 2005, 2006 | Major problem | Orchards and savannah's |
| Grenada | 1996, 1997, 1998, 2005* | Low to medium, Problematic | Wastelands |
| Guyana | 1998 | Major problem | Wastelands |
| Jamaica | 1996 | Moderate | Wastelands |
| Kenya | 1987 | Moderate | Wasteland |
| Mexico | 1989 | Low | Waste and cultivated land |
| Montserrat | 1998 | Low | Road sides, wastelands |
| Nepal | 2002, 2006 | Very low | Roadsides |
| Saint Kitts and Nevis | 1996 | Low | Wasteland, vegetable fields and road sides |
| South Africa | 2005, 2006 | Medium | Wastelands |
| Suriname | 1998 | Moderate | Wastelands and roadsides |
| Trinidad and Tobago | 1996, 1998, 2005** | Low to moderate, Problematic | Waste land and roadsides |
| USA | 1987, 1992 | Very low | Abandoned land |

* – respondent Andall, A; **-respondent Maraj, C (Surveyed through E. Mail)

- Presence of allelopathic properties to suppress native vegetation.
- Photo and thermo-insensitivity.
- Rapid colonizing and dominating nature.
- High drought and water stress tolerance.
- Greater ability to grow in diverse ecological conditions (seen to grow from higher altitude of Kullu Valley to sea level in Chennai).
- Extremely light- weight, capacity to float and armed with pappas, are some of characteristics of the seed, which help its extensive spread.
- Hazardous to crops, human and animal health, which restricts its manual removal.

Besides above, the plant normally completes its life cycle within 4 months. However, its periodicity depends upon frequency and distribution of rain during

the year. The young leaves pressed closely to ground offer severe competition and does not allow other plant species to come up. Flowering commences within a month of sprouting of seeds and continues throughout the year.

## Need to Eliminate *Parthenium*

(a) *Parthenium* is well known to cause contact dermatitis, skin allergy, eczematous dermatitis, rhinits, nasal and bronchial asthma hay fever in human beings due to the presence of water soluble lactones and flavenoids. These diseases may be caused by repeated contact with weed or with its parts particularly pollens. A slight physical contact with this weed in very sensitive person is said to cause/develop swelling and blisters on exposed/contacted part of the body. Its air borne dried material may also perpetuate dermatitis in very sensitive human beings. Generally, adult males are mainly affected by this weed as compared to females. However, children below twelve years of age are, often spared.

(b) The studies conducted on the toxicity of the weed to cattle at various institutions *viz.*, Indian Institute of Science, Bangalore and at Delhi University showed that *Parthenium* causes intestinal ulcers in grazing animals and reduces milk yield. Milk also contains a poisonous substance "Parthenin" and develops "Bitter Milk". Its accidental or willful intake for want of green fodder may cause severe disease syndrome and prove fatal to grazing animal.

(c) *Parthenium* removes a major portion of nutrients and depletes soil fertility and reduces crop yield considerably.

(d) It affects nodulation in legumes due to inhibition of activity of nitrogen fixing and nitrifying bacteria *viz.*, *Rhizobium* and *Azotobacter.*

(e) Its pollen inhibits pollen germination and fruit setting in many vegetables *viz.*, brinjal, chili and tomato.

## Management

Various methods of weed control *viz.*, physical, mechanical, chemical and biological have been practiced normally in isolation for its control, however, with a limited success. An integrated approach involving physical, chemical and biological methods alone can offer an effective control strategy.

### *(a) Physico-mechanical Method*

Repeated manual uprooting of this weed before flowering provides immediate but temporary control. Manual removal should be carried out before flower and fruit setting particularly when the soil is wet to prevent further re-enforcement of its seed to the soil and dispersal to newer areas. It is suggested to form a 'Task Force' from among school children who are spared from its ill effects for manual eradication programme in the residential premises/parks. Large-scale use of this technique is expensive, impracticable and highly risky, as it needs the use of gloves and protective clothing to avoid physical contact with sensitive people as precautionary measures. Moreover, partial pulling of stem encourages regeneration and repeated removal at least for a season-long control.

### *(b) Chemical Method*

Remember, chemicals provide fast but short-term control. Besides, these are expensive, non-ecofriendly and require knowledge of spray technology. Moreover, these are less effective in cases where seeds are already deposited in soil. Also, special care has to be taken to avoid spray drift risk to adjoining sensitive crops. Chemicals/ herbicides found effective against *Parthenium* control in cultivated and non-cultivated areas are metribuzin (1000 and 1500 g ai/ha) or glyphosate @ 2000g ai/ ha (Sharma and Gautam, 2004). Widely used herbicide (paraquat) is no more effective now against white top due to resistance. These may be replaced with urea (20% water solution) common edible salt lumps (15% water solution) for control of weed in non-cropped areas.

### *(c) Biological Method*

(1) *Use of Botanical Agents:*

In this method living things (allelopathic plants, insect, fungus etc.) are used to suppress the growth of this weed. Infestation of *Parthenium* can be suppressed by increasing the density of the existing natural vegetation like *Ipomoea* spp., *Acacia* spp. especially in the city forests, as it can not compete with dense natural vegetation. Use of plants possessing negative allelopathic effects is an important component of biological control of weeds wherein presence of one plant suppress the growth of other plants growing in the same habitat (Kohli and Kumar, 1997).

Botanical survey done across the country has revealed the negative allelopathic effect of following species in

suppressing *Parthenium* in natural habitats. *Cassia sericea* SW., *C. tora* L., *C. auriculata* L., *Croton bonplandianum* Baill (*C. sparsiflorus* MaL), *Amaranthus spinosus* L., *Tephrosia purpurea* L. (best for arid region), *Hyptis suaveolens* Pois, *Sida spinosa* L., *Myrablis jalapa, Ipomoea* spp. and *Stylosanthes haemata.* Amongst the above species *C. sericea,* an exotic plant has been proved most effective botanical agent in controlling *Parthenium* substantially and perpetuates on its own in the forthcoming years. Its effects on *Parthenium* were confirmed through laboratory and field studies. In fact, plant leachates of C. *sericea* have "Kolines" which accumulate in the soil and inhibit the germination and growth of *Parthenium.* After establishment of *Cassia, Parthenium* growth subsides gradually to the point of elimination. Unlike *Parthenium, Cassia* is useful in many ways. It is important to identify botanical agents specific to each situation in all the regions where this weed is problematic. For instance, *Kochea indica* (earlier reported as *Chenopodium album*) is a viable option for Delhi and North Indian conditions (Gautam *et al.*, 2005c) as against *C. sericea.*

(2) *Use of insect Agents*

Use of insects is another important component of its biological control, which appeared from several surveys in the Caribbean (Mc Clay, 1981). A leaf eating beetle, *Zygogramma bicolorata* Pallister (Chrysomelidae: Coleoptera) introduced from Mexico (known as mexican beetle) is found highly specific to the *Parthenium.* Interestingly, its larvae and adults are helpful in reducing *Parthenium* growth through feeding. The beetles cause large-scale defoliation under tropical weather (Jayanth and Bali, 1994; Sushilkumar *et al.*, 1998).

The Mexican beetle was introduced in Delhi in September 2001 in order to suppress *Parthenium* at a prevailing temperature of 20°-38°C and 39-73% relative humidity. The operation was covered in the daily newspapers as big event (Bhatnagar, 2001; Kumar, 2001), wherein several persons having environmental concern participated. The beetles were also released at the research fields of the Indian Agricultural Research Institute, New Delhi, during September 2001 and were found multiplying at 3 out of 5 release sites till the end of October 2001 (14.4-36.4°C and 41-66% RH). The beetle remained unnoticed with decline in day temperature during the winter, though in the laboratory, at 26±2°C and 60±10% R.H, it continued breeding without over wintering. Adults approaching over wintering laid few eggs up to third week of the November (temperatures ranging from 9.4° to 35.4°C and relative humidity ranging from 61-93%), which failed to hatch afterwards. No egg laying was observed during foggy and chilling weather in December 2001 with a minimum and maximum temperature between 8 to 17.2°C and 22.2°C to 35°C, respectively. Non-over wintering females showed profuse egg laying continuously during chilling weather up to 3 days when released on *Parthenium* plants grown in pots. Survival of scanty adults during chilling weather as well as scorch summer at Delhi thus suggests that even though *Parthenium* beetle is unlikely to reproduce, its establishment can not be ruled out (Gautam, 2002).

Interestingly, surveys carried out during December 2004 and January 2005 revealed that beetles are active even in cooler months (Gautam, 2005). These were seen in some places as mating, laying eggs and developing larvae indicating that the population has acclimatized. By end of 2006, beetle has well established in Delhi and its neighboring states, remain active through out the year and noticed naturally spreading without entering into diapause/hibernation/aestivation (Gautam *et al.*, 2005 a, b; Gautam *et al.*, 2006; Bhoopathy and Gautam, 2006).

## Judicious Use of Mechanical Method

Its large-scale menace can be solved to some extent by deploying mechanical control in small pockets, isolated places, uprooting isolated plants through public participation. However, it should be deployed carefully and judiciously as a component.

## Integrated *Parthenium* Weed Management

All the above techniques should be adopted simultaneously in an integrated manner so that the spread of *Parthenium* and its harmful effects could effectively be reduced. Besides, some of the major operational tips for controlling *Parthenium* at a glance are listed here.

- Mark the boundary of the area in which *Parthenium* is to be controlled/treated.
- Maintain natural biodiversity and avoid undue disturbances of natural habitat except *Parthenium.*
- Uproot the *Parthenium* plants before flowering on the day after a rainy day for easy removal.
- Open the shallow furrows about 2.5 cm deep and 22.5 cm apart and sow the scarified seeds of *C.*

*sericea* @ 15 kg/ha and cover the furrows just before the onset of rains.

- Continue the uprooting of *Parthenium* plants/ seedlings at 3-4 weeks interval so as to enable *C. sericea* and other vegetations to put up full growth and cover.
- Once *C. sericea* is established, it will spread and grow on its own and perpetuate.
- Release 10,000-15,000 Mexican beetle, a bio-agent for 1 ha of *Parthenium* infested land.

## Suggested Strategies

1. *Parthenium* continues to spread undisturbed in public, waste, abandoned fallow lands in residential and industrial premises and in lawns. Therefore, individuals may not have any interest and capable in controlling it. Hence, ensure to pay special attention to launch Community / Public Awareness Campaign jointly by Government and Voluntary organizations (NGO's) with active public participation. Flourists may be educated about its ill effects and advised not to use *Parthenium* florets in bouquets as it causes certain allergies as and when placed in the rooms.
2. Bringing out legislation similar to that of mosquito control in order to fix responsibility to the public, Municipal Corporations and other responsible public/ private sector bodies in order to assist in the management of Parthenium Plague.
3. Basic studies on mode of action of parthenin and other constituents of the weed.
4. In cultivated land, grow highly competitive species or varieties in cropped areas coupled with regular cultural practices along with use of specific recommended herbicides for its suppression.

## References


Agarkar SV (1999) A survey of *Parthenium* competitive plants for environmental protection. *Environment and Ecology* **17(1):** 228-229.

Arny (1897) *Parthenium hysterophorus* L. *J. Pharm.* **69**:168.

Bhatnagar G (2001) Extra-ordinary war and extra ordinary warriors. *The Hindu*, a daily newspaper, September 20, 2001, pp.1.

Bhoopathi Rand RD Gautam (2006) Effect of temperature on biological attributes of *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae). *J. Ent. Res.*, **30(3):** 255-258.

Castex MF, MF Moltino and Moreno Ruiz (1940) Primera contributional estudio de la flora alergogena de la Repubilca Argentina. *Parthenium hysterophorus*: note previa First contribution to the study of the allergic flora of the Argentinian Republic, *Parthenium hysterophorus*. *Bol. Acad. Nac. de med. de buenos Aires* pp.91-96.

Chandras GS and VD Vartak (1970) Symposium on problems caused by *Parthenium hysterophorus* in Maharashtra region, India. *PANS*, **16**: 212-213.

Chandra S (1973) Parthenium-a new dermatitic weed in Bihar. *Proc. Sixteenth Indian Sci. Congress* III P. 375.

Dale IJ (1980) The habitats of *Parthenium hysterophorus* L. in South America, Mexico and the United States of America compared with the Queensland environment. Alan Fletcher Research Station, Sherwood, Queensland pp.14.

Gautam RD (2002) Investigations on the release of exotic beetle for control of *Parthenium hysterophorus* in Delhi. *Indian J. Weed Sci.*, **34(3&4):** 259-263.

Gautam RD (2005) Advances in Parthenium Beetle, *Zygogramma bicolorata* Research and Field Utilization. In Second International Conference on Parthenium Management, held at University of Agricultural Sciences, Bangalore, 5-7 December, 2005, pp 170-176.

Gautam RD, Arun Samyal and Md Aslam Khan (2005a) Changing status of diapause in *Zygogramma bicolorata* Pallister in North India *Ann. Pl. Protec. Sci.*, **13(2):** 343-346.

Gautam RD, Arun Samyal and Md Aslam Khan (2005b) Release, recovery and establishment of mexican beetle, *Zygogramma bicolorata* Pallister (Chrysomelidae: Coleoptera) in and around Delhi on *Parthenium hysterophorus* Linnaeus. *J. Ent. Res.* **29(2):** 167-172.

Gautam RD, Md Aslam Khan, Arun Samyal, AK Garg, M Mahadevappa and Rajvir Sharma (2005c) Survey of the plants suppressing *Parthenium hysterophorus* Linnaeus in Delhi. In Second International Conference on Parthenium Management, held at University of Agricultural Sciences, Bangalore, 5-7 December, 2005, pp 94-97.

Gautam RD, Md Aslam Khan and AK Garg (2006) Ecological adaptability and variations among population of Mexican beetle, *Zygogramma bicolorata* Pallister (Chrysomelidae: Coleoptera). *J. Ent. Res.*, **30(1):** 21-23.

Jayachandra (1971) Parthenium weed in Mysore State and its control. *Curr. Sci.* **40**: 568-569.

Jayanth KP and G Bali (1994) Biological control of *Parthenium hysterophorus* by the beetle *Zygogramma bicolorata* in India. *FAO. Pl. Protec. Bull.* **42(4):** 207-213.

Joshi S (1991) Intereference effects of *Cassia uniflora* Mil. on *Parthenium hysterophorous* L. *Pl. Soil,* **132**: 213-218.

Kanchan SD and Jayachandra (1975) Allelopathic effects of *Parthenium hysterophorous* L. I exudation of inhibitors through roots. *Pl . Soil* **53**: 27-35.

Kohli RK and S Kumar (1997) Control of *Parthenium hysterophorus* L. through allelochemicals from a few multipurpose exotic trees. *First international conference on Parthenium management*, Dharwad, India 6-8 October 1997, pp. 37-39.

Krishnamurthy K, TV Ramchandra Prasad, TV Muniyappa and BV Venkata Rao (1977) *Parthenium*, a new pernicious weed in India. *UAS, Tech. Ser.*, No **17**: pp 66.

Krishnamurthy K, TV Ramchandra Prasad, TV Muniyappa (1976) Ecology and control of *Parthenium. Proc. of Seminar on Parthenium a Positive Danger,* Bangalore (India). September 4, pp. 8-10.

Kumar M (2001) Beetles join grim battle against deadly weed, *Hindustan Times* South Delhi Live, September **22**: pp 1.

Mackoff S and AOA Dahl (1951) Botanical consideration of the weed oleoresin problem. *Minn Med.* **34(12):** 1169.

Mahadevappa M (1999) *Parthenium* and its Management. Publication Centre, *Univ. Agric. Sci.,* Dharwad, India, 132p.

Mahadevappa M (1996) *Parthenium Prasaranga*, University of Mysore, Mysore, p. 66.

Mahadevappa M and H Ramaiah (1990) Pattern of replacement of *Parthenium hysterophorus* plants by *Cassia sericea* in waste lands. *Indian J. Weed Sci.,* **20**: 83-85.

Maheshwari JK and RS Pandey (1973) *Parthenium* weed in Bihar State. *Curr. Sci.*, **42**: 733.

Mamatha M and M Mahadevappa (1992) Biological survey in relation to *Parthenium* control. *Advances in Pl. Sc.*, **5:** 426-429.

Mc Clay AS (1981) Studies of the natural enemies of *Parthenium hysterophorus.* Trinidad-and-Tobago, Common Wealth-Institute-of-Biological-Control: Report-of-work-carried-out-April-1980-March-1981, 62-63. *Commonwealth Agricultural Bureaux.* Slough; UK.

Narsimhan TR, M Ananth, M Narayanaswamy, R Babu, A Mangla and PVS Rao (1980) Toxicity of *Parthenium hysterophorus*: Partheniosis in cattle and buffaloes. *Indian J. Anim. Sci.* **50**: 173-178.

Ogden HD (1957) Diagnosis and treatment of parthenium dermatitis. *J La State Med Soc.* **109(10)**: 378-379.

Parihar SS and KC Kanodia (1986) *Parthenium hysterophorus*-A review of Indian work. *My Forest*, **22**: 51-59.

Rao RS (1956) *Parthenium*-a new record for India. *J. Bombay Nat. Hist. Soc.* **54**: 218-220.

Sharma R and RD Gautam (2004) Problems and management strategies for the control of congress grass. *Indian Farming* **53(10):** 17-21.

Sushilkumar, VM Bhan and S Kumar (1998) Establishment and dispersal of introduced exotic beetle *Zygogramma bicolorata* in relation to ecological factors at Vindhyanagar. *Indian J. Ecol.* **25(1):** 8-13.

Tiwari JP and CR Bisen (1984) Ecology of *Parthenium hysterophorus* L. *Indian J. Weed Sci.* **16**: 203-206.

Towers GHN, JC Mitchell, E Rodriguez, FD Bennett and PV Subba Rao (1977) Biology and chemistry of *Parthenium hysterophorus* L., a problem weed in India. *J. Sci. Ind. Res.* **36**: 672-684.

Towers GHN and PVS Rao (1992) Impact of the pan-tropical weed, *Parthenium hysterophorus* L. on human affairs. *Proceedings of the 1st International Weed Control Congress,* **1:** 134-138, Weed Science Society of Victoria; Melbourne; Australia.

Vaid KM and HB Naithani (1970) *Parthenium hysterophorus* L.: A new record for the North Western Himalaya. *Indian Forester* **96**: 791-792.

Vartak KD (1968) Weed that threatens crop and grasslands in Maharashtra. *Indian Farming* **18(1):** 23-24.