Research Article

Distribution Pattern and Management Strategy of Invasive Weed *Parthenium hysterophorus* L. in Gorakhpur, India

Snehlata Tripathi[1], Satish Kumar Rai[2], Sanjay Kumar Pandey[1,*]

[1]Department of Botany, DAV PG College, Gorakhpur, Uttar Pradesh, INDIA.
[2]Department of Botany, Government PG College, Bina, Madhya Pradesh, INDIA.

Submission Date: 19-02-2023; Revision Date: 12-03-2023; Accepted Date: 15-03-2023.

ABSTRACT

Background: *Parthenium hysterophorus* L. (Family Asteraceae, local name Chatakchandni), an invader weed, assumes importance and poses a problem because of its nuisance value. The present study accounts for its population structure, community relation and its probable association with neighbour species within the major grassland vegetation types of the region. **Materials and Methods:** For the study of population status, phytosociological characters, neighbour relations of *Parthenium* and its contribution to the two major grasslands' the managed and natural were calculated by the standard sampling methods. **Results:** Highly disturbed or completely cleaned sites may be fast colonized and aggregated by *Parthenium,* as evident from the values of its phytosociological attributes. In natural grassland, however, the number of species as the nearest neighbour of *Parthenium* was quite high. *Parthenium* was found to occur at all different stages of growth and at every stage of its life cycle throughout the year. In the months of July, November and March, a much greater number of individuals were in the seedling stage. **Conclusion:** Since there is no lapse period between seed dispersal and germination, effective management may be exercised only before they enter the reproductive phase. Since there is no mode of asexual regeneration in this species, manual elimination must be held at juvenile stage to get an area rid of this noxious weed.

Keywords: *Parthenium*, Population, Grassland, Nearest neighbour, Association.

Correspondence:
Dr. Sanjay Kumar Pandey,
Department of Botany, DAV PG College, Gorakhpur-273001, Uttar Pradesh, INDIA.

Email: drskp27@gmail.com

INTRODUCTION

Weeds assume importance and pose a problem because of their nuisance value.[1] Being an integral component of the croplands and wastelands, weeds greatly influence the general organisation and functioning of ecosystems.[2] It has been argued that the information gathered on the ecology of weeds may prove helpful in designing efficient control measures.[3] The invasion of native ecosystems by exotic species is a well-known phenomenon. Several exotic species, unknowingly brought as contaminants of a variety of materials transported from other geographical regions, can alter the population and community structure of native ecosystems.[4] Drastic changes in the micro-environment apparently prevent the establishment of native species, and aggressive invaders like *Lantana, Mikania* and *Parthenium* monopolize the environment under such situations.[5,6] Prolonged occupation of a site by these exotic weeds may repeatedly deflect or arrest the normal course of vegetation development.

At present, *Parthenium hysterophorus* is the most noxious invader of the natural vegetation of north-eastern U. P.[7,8] The species grows abundantly as a weed in all sorts of available non-cultivated, open lands, but the status of its population in grassland communities is largely unknown. The present study accounts for its population structure, community relation and its probable association with neighbour species within

SCAN QR CODE TO VIEW ONLINE

www.ajbls.com

DOI: 10.5530/ajbls.2023.12.19

the major grassland vegetation types of the region. Observations on its growth pattern and phenology have also been made. The information on the above attributes is likely to provide some clues about the cause of the versatility of this weed and may be helpful towards the efforts to control it.

MATERIALS AND METHODS

The study site (25° 5' and 27° 9' N latitude, and 83° 4' and 84° 26' E longitude at 95 m above sea level) represents a typically monsoonic climate with an average annual rainfall of about 1814 mm (87% rainfall during monsoon period). The mean maximum temperature during wet summer (July to September), winter (October to February), and dry summer (March to June) season is 35.2°C, 27.6°C and 39.3°C, and the mean minimum temperature is 26.2°C, 12.1°C and 24.2°C respectively. The soil is an old gangetic alluvium. The texture is sandy loam, and the soil reaction is nearly neutral.[9]

For the study of population and neighbour relations of *Parthenium* and its contribution to the phytosociological characters of the two major grasslands' the managed and natural were considered. The quantitative characters (frequency, per cent vegetal cover and IVI) of *Parthenium* were calculated by the methods given by Mueller-Dombois and Ellenberg.[10] The sampling was made through square quadrats (each of 20 cm × 20 cm). At least 50 such quadrats were observed for each community type. The per cent contribution of *Parthenium* towards the concentration of dominance (cd) and species diversity (H) was also derived through a suitable method. cd was measured by Simpson's index, and species diversity was calculated on the basis of the Shannon-Wiener index.[11]

For the analysis of spatial or neighbourhood relations, the plant-eye-view approach of Turkington and Harper[12] was adopted. Ready-mades hardwire circles of 25 cm radius were used for defining the limit of the neighbourhood zone. An individual of *Parthenium* at the centre of a circle was considered as the reference point (or target plant), and the surrounding ones, including those of target species within this circle, were considered as neighbours. The three growth stages, seedling stage, vegetative stage and mature stage, were considered as target plants of *Parthenium*. This distance of nearest neighbours (both conspecific and heterospecific) from the target plants and the density of different neighbour species within this neighbourhood zone was recorded. The distance between the target plant and its nearest neighbour and their sizes were recorded. The association of *Parthenium* with different neighbour species was tested on the basis of the presence/ absence of both or either of the species through X using a 2 X 2 contingency table.

As *Parthenium* at different sites showed individuals of all growth stages at any time of the year and even at the same time, the proportions of the species was determined in different months (Jul., Nov., Dec., Jan., Mar., Apr., May., and June) of the year. A grassland belt of 10m (5m × 2m) was marked on the University campus. All the individuals occurring within the area were counted and sorted out according to their growth stages under 5 categories- 4-leaf stage (4-L-S), Rosette-Leaf Stage (RLS), Vertical-Growth Stage (VGS), Flowering Stage (FLS) and Fruit-Dehiscence Stage (FDS). The vegetative phase was considered completed just before the time of flower initiation. The flowering phase was regarded as completed when ~ 50% of the total heads per plant were apparent. The fruit dehiscence phase was identified as a point at which >50% of heads were dehisced the per cent number of individuals under different phases stacked as horizontal bars of the species in different months.

RESULTS

The present study represents some quantitative characteristics of grassland communities which includes *Parthenium* in different abundance. Figure 1 shows the contribution of *Parthenium* to various indices of grassland communities of different sites. In general, these values were very low for major grassland. While the frequency and per cent vegetal cover were closely similar for site one and site 2, a mark difference was noticed in density and IVI. The density of *Parthenium* was greater for site 2 and IVI for site 1. The share of the *Parthenium* to the values of dominance (cd) and α- diversity (H-) was also low in natural and managed grasslands. While the per cent contribution to α- the diversity of the community was very close for the two sites (1.2% for natural and 1% for managed grassland) but the managed site (0.24%) contributed much lesser towards the dominance (cd) of the community as compared to the natural site (1.1%).

Both grasslands, however, had a considerable number of species as the nearest neighbour of *Parthenium*. The distance between *Parthenium* as a target plant at different stages (seedling, vegetative and flowering) and the nearest individuals among neighbours, as given in (Table 1) showed that the species more frequently encountered as nearest neighbours had lesser Nearest Neighbour Distance (NND) as compared to the species occurring as less frequent nearest neighbours. Thus, the less frequent species like *Boerhavia, Launea, Cassia*

Table 1: Nearest neighbour distance of neighbour species in different stages of *P. hysterophorus* as target plant at site I and II.

Nearest neighbour species	Nearest neighbour distance (Mean ± SD) cm					
	Natural site			Managed site		
	Seedling	Vegetative	Flowering	Seedling	Vegetative	Flowering
Achyranthes aspera	-	2± 0.6	3± 1	-	-	-
Amaranthus spinosa	-	-	-	-	6± 0.5	7± 0.6
Boerhavia difffusa	-	12± 2.6	-	-	-	-
Cassia occidentalis	-	7.5 ±1.6	-	-	-	-
Evolvulus nummularious	-	3± 1	4.3± 0.5	2 ±0.2	-	1± 0.3
Eclipta erecta	2.6± 0.2	-	-	2± 0.2	2± 0.4	2± 0.4
Euphorbia hirta	-	3± 1	3± 0.5	4± 0.8	6± 1.2	3± 0.2
Gomphrena globose	-	-	-	-	1± 0.4	-
Launea asplanifolia	-	-	8± 2	-	-	-
Lindernia bracheata	1.6± 0.5	2.3± 0.8	1.8± 0.2	2± 0.3	2± 0.5	2± 0.5
Oxalis corniculate	3± 0.3	3.3± 0.2	2± 0.2	2.6± 0.2	-	1± 0.2
Ocimum canum	-	7± 0.2	5± 0.5	-	-	-
Parthenium hysterophorus	3.5± 0.6	4± 0.6	4± 1.8	2.6± 1.2	8± 1	4± 0.4
Rungia pectinate	-	4± 1.2	5± 1.5	3± 0.5	-	3± 0.6
Sida acuta	5± 0.8	3± 0.4	-	4.5± 0.3	9± 2	-
Sonchus aspera	4.5± 1.2	-	-	3.4± 0.4	-	-
Veronia cinerea	-	-	-	-	9± 2	8± 1
Xanthium strumarium	-	8± 1	-	-	-	-

occidentalis, Ocimum and *Xanthium* were generally located at a greater distance as compared to more frequent species like *Oxalis, Evolvulas, Rungia* and *Achyranthes*. These were located at a lesser distance but encountered more frequently as the nearest neighbour of *Parthenium*. The greater nearest neighbour distance was observed at the vegetative stage of *Parthenium* as compared to other stages at both sites. The maximum neighbour density at the seedling stage of the target plant may be due to much lessor competition at this stage. At the managed site, the density of neighbours was considerably high despite greater canopy cover. At the seedling stage, the density of *Parthenium* as the conspecific neighbour was greater at the managed site. Due to regular and high disturbance levels, the number of *Parthenium* also decreased, leaving only a few individuals to reach to flowering stage. But at the natural site, however, though the germination and establishment of seedlings were less, most of the established seedlings were able to survive and complete their life cycle. However, the species with individuals of prostrate habit could better survive as its nearest neighbour. The degree of association of different nearest neighbours with Parthenium based on a 2x2 contingency table was observed at both sites (Table 2). The association was significant with *Oxalis,*

Table 2: Association of common nearest neighbour species with *P. hysterophorus* in major grassland. The values of association index marked with asterisks are significant at 5% probability level at df= 1.

Nearest Neighbour species	X^2 - association	
	Site- I	Site- II
Oxalis corniculate	5.8*	6.2*
Sonchus aspera	4.2*	3.9*
Evolvulus nummularious	3.8*	4.4*
Rungia pectinate	1.1	4.1*
Sida acuta	1.5	1.5
Euphorbia hirta	0.61	0.86
Lindernia bracheata	0.08	0.73

Sonchus and *Evolvulas* at a 5% probability level at both sites, but for *Rungia*, it was significant only at site II. The association index with *Lindernia* was minimum at both sites. The density/m^2 of all the neighbours within the circular neighbourhood zone (r = 25 cm) was found to be maximum when the target plant (*Parthenium*) was in the seedling stage and minimum when it was in the flowering stage at both sites. The site-related differences in neighbour density were clear only at the vegetative stage of the target plant; neighbour density was very high at site I as compared to site II. The per cent

Table 3: Number of individuals/m² of neighbour species and per cent contribution of *P. hysterophorus* as neighbour within a circular (r= 25 cm) neighbourhood zone of *Parthenium* as target plant at different growth stages at major grassland.

Stages of target plant	Site	Diameter of target plant (cm)	Density/ m²	% Contribution of *Parthenium* in density
Seedling stage	I	6 ± 0.6	153.7	59%
	II	5.2 ± 1.2	149.1	27%
Vegetative stage	I	21.4 ± 6.2	127.3	44%
	II	11 ± 5.9	60.6	47%
Flowering stage	I	38.3 ± 4.2	40.4	25%
	II	33.3 ± 5	47.2	30%

contribution of *Parthenium* as a neighbour individual was much greater at site I when the *Parthenium* as target plant was in the seedling stage, but it was comparatively high at site II, when the *Parthenium* as target plants were in the vegetative and in flowering stage (Table 3).

The proportion of individuals at different stages of growth often varied significantly in different months. In January, the proportion of very young seedlings and old individuals showing fruit dehiscence stage was much lesser as compared to those in the full vegetative stage. In a subsequent month, the greatest proportion of young seedlings and least of senescing ones was present. April witnessed an inverted condition in which the proportion of old and older age increased, but the number of individuals at rosette – leaf stage, vertical–growth stage, flowering stage or fruit–dehiscence stage did not increase very much. The proportion of individuals at 4 – the leaf stage was the least. The proportion of individuals changed to a perfectly inverse shape in May with a minimum number of young seedlings and a maximum number of senescing plants. The shift towards older growth continued in June without any recruitment of new individuals. The proportion of senescing plants became maximum in the peak summer period of June. During the month of July, however, the old individuals were absent, and the vegetative stage prevailed with a maximum number of 4 – leaf stage plants. In the months of September, the proportion again turned to be inverse except for the number of senescing plants, which remained quite low. There was heavy recruitment probably during October, which changed the situation in November but without any individual at the flowering or fruit dehiscence stage.

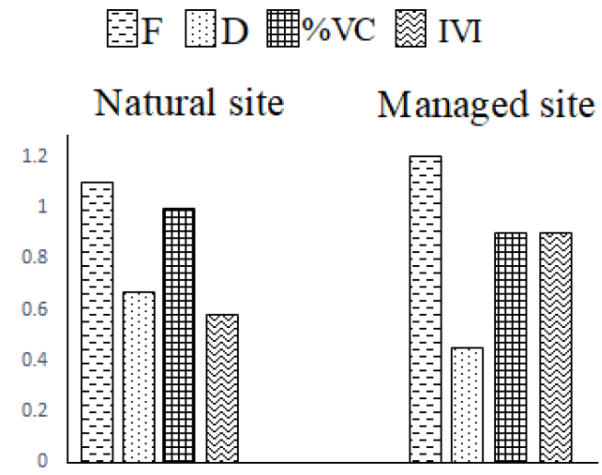

Figure 1: Per cent contribution of *P. hysterophorus* to sum of Frequency (F), Density (D), % Vegetal Cover (%VC) and Importance Value Index (IVI).

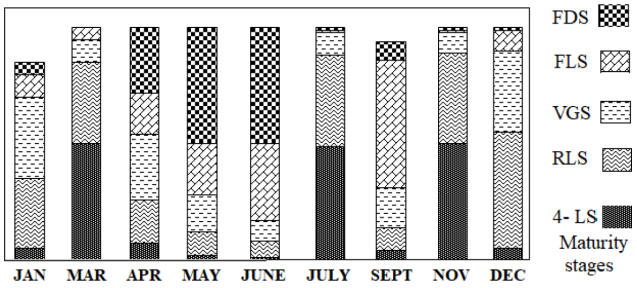

Figure 2: Proportion of *P. hysterophorus* in different months of the year. Each horizontal bar shows the percent number of individuals falling under five different maturity stages. 4-L-S: 4-Leaf Stage; RLS: Rosette-leaf stage; VGS: Vertical- Growth Stage; FLS: Flowering Stage; FDS: Fruit- Dehiscence Stage.

It appears that there was no recruitment in November or December (Figure 2). It may be observed that the weed was either very thin or absent only before the onset of rains (June- July), and once it started in July, it completed its first life- cycle during July – October; second, during November – February and third during March – June.

DISCUSSION

Parthenium fails to establish well in presence of good grassland vegetation. An important requirement for successful colonization of invaders is open habitats with reduced competition. IVI of Parthenium was comparatively higher at managed site, which may be attributed to the high level of disturbance. A few species like *Amaranthus, Gomphrena* and *Vernonia* were also encountered as nearest neighbour but only at managed site and were located at much greater distance from *Parthenium*. Highly disturbed or completely cleaned sites may face aggregation of *Parthenium* as evident from

the values of its phyto-sociological attributes. Thus, Parthenium monopolize the open ground surface as aggressive invaders often do in such environment.[2] The density of conspecific neighbour was, therefore, much higher at this site. The sharing of available resources is directly proportional to the number and proximity of neighbouring species which are already present in the surrounding.[13] The species like *Vernonia*, *Xanthium*, *Boerhaavia*, *Launea* and *Cassis* showed much lesser presence as nearest neighbour of Parthenium and were more frequent species like *Oxalis*, *Rungia*, *Sonchus*, *Evolvulus* and *Parthenium* itself. > 50% of the total species were encountered as nearest neighbours.

Seeds of *Parthenium* do not have dormancy period and have capacity to germinate anytime where even moderate moisture is available. Germination of seeds take 6 to 8 days during monsoon and anthesis starts after 30 days and continues to next 90 days. In natural grassland, the number of species as nearest neighbour of parthenium was quite high. It may be possible because of the fact that the vertical growth of the *Parthenium* facilitated by low disturbance caused little interference to a verity of neighbours. On the other hand, the disturbed playground which suffered greater disturbance witnessed much lesser number of nearest neighbours probably due to the more prostrate rosette-shaped vegetative growth of *Parthenium* posing greater interference to its neighbours. A few studies of such interference affecting neighbour is available in case of woody plants.[14]

Extensive studies of germination and early mortality especially with regard to density dependent factors, have been done by several workers in various grasslands.[15] The above studies have proved that the abundance of a particular species in an area is determined by the availability of seeds, seed dormancy mechanisms, the number of suitable microsites for germination, the ability of the seedlings to tolerate physical features of the environment and the ability to withstand interference from the plants. After establishment the individuals of *Parthenium* under vegetative stage, showed the least mortality as there was no paucity os space related resources. At both the sites, the adult mortality was negligible and it became significant only when the individual completed fruit setting. The observed mortality was caused probably by the limitation of space-related resources.

Parthenium is an aggressive invader, but it fails to significantly establish an area with good ground cover. Its elimination from the site of its noxious presence may be made possible by uprooting the individuals still under vegetative phase. The different periods of the year during which it is predominantly in vegetative phase are clear from its age pyramids. Since, there is no lapse period between seed dispersal germination the effective control lies in the fact that the individuals must be removed before they enter the reproductive phase as there is no mode of asexual regeneration in this species. Successful management of *Parthenium* can only be achieved by an integrated approach with biological control as the key element.

CONCLUSION

Parthenium was found to occur in all different stages of growth and at every stage of growth and at every stage of its life-cycle throughout the year. Seeds were mostly viable without any period of seed dormancy and could withstand temperature fluctuations ranging from winter to summer. After establishment, the individuals of *Parthenium* under the vegetative stage showed the least mortality as there was no paucity of space-related resources. The effective control lies in the fact that the individuals must be removed before they enter the reproductive phase, as there is no mode of vegetative regeneration in this species except for occasional sprouting stumps. The introduction of suitable indigenous species, at a stage when the vigour of the *Parthenium* is reduced, could be a method of control of this noxious weed.

ACKNOWLEDGEMENT

The authors are highly thankful to Prof. R. P. Shukla, DDU Gorakhpur University, Gorakhpur for guidance of the study and identification of grassland species. Special thank are due to Head, Department of Botany, DDU Gorakhpur University, Gorakhpur and Prof. Shail Pande, Principal, DAV PG College, Gorakhpur for facilities and encouragement.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

NND: Nearest neighbour distance; **IVI:** Importance Value Index; **4-L-S:** 4-Leaf Stage; **RLS:** Rosette-leaf stage; **VGS:** Vertical-Growth Stage; **FLS:** **F**lowering Stage; **FDS:** Fruit- Dehiscence Stage.

REFERENCES

1. Tripathi RS. Weed problem an ecological perspective. Trop Ecol. 1977;18:138- 148.

2. Ramakrishanan PS. Ecology of biological invasion in the tropics (ed). New Delhi: ISP; 1991.
3. Adkins S, Shabbir A, Dhileepan K. Parthenium weed: biology, ecology and management. Wallingford: CA B International. ISBN 9781780645254; 2019.
4. Raghubanshi AK, Rai LC, Gaur JP, Singh JS. Invasive alien species and biodiversity in India. Curr Sci. 2005;88:539-540.
5. Saxena KG 1991.... Biological invasions in the Indian subcontinent: a review of invasion by plants. In: Ecology of biological invasion in the tropics, (ed) Ramakrishnan, PS. Pp 53-73. 1991.
6. O'Donnell C, Adkins SW. Management of Parthenium weed through competitive displacement with beneficial plants. Weed Biol Manage. 2005;5(2):77-79. doi: 10.1111/j.1445-6664.2005.00160.x.
7. Tripathi S. Plant diversity of grasslands of north-eastern U.P. with emphasis on populations of *Parthenium hysterophorus* L. [Ph.D. thesis], DDU Gorakhpur University. Gorakhpur; 2000.
8. Pandey SK, Shukla RP. Competitive ability and neighbour relation of *Parthenium hysterophorus* with *Crotalaria striata*. Indian J Ecol. 2018;45(4):826-830.
9. Shukla RP, Pandey SK. Vegetation and plant diversity. New Delhi: SSPH; 2020, P.-232.
10. Mueller-Dombois D, Ellenberg M. Aims and methods of vegetation ecology. New York: John- Wiley and Sons; 1974.
11. Magurran AE. Ecological diversity and its measurement. London: Croom-Helm; 1988.
12. Turkington RA, Harper JL. The growth, distribution and neighbour relationship of *Trifolium repens* in a permanent pasture II. Inter and intra-specific content. J Ecol. 1979;67:219-30.
13. Tilman D. Niche trade-offs, neutrality, and community structure: A stochastic theory of resource competition, invasion, and community assembly. Proc Natl Acad Sci U S A. 2004;10(30):10854–10861.
14. Tiwari AK, Shukla RP. On the neighbourhood relationships of two common understorey trees of a *Shorea robusta* community. Ann Bot. 1995;75(2):127-132. doi: 10.1006/anbo.1995.1003.
15. Tripathi S, Shukla RP. Effect of clipping and grazing on various vegetational parameters of grassland communities of Gorakhpur, U.P. Trop Ecol. 2007;48(1):61-70.

Cite this article: Tripathi S, Rai SK, Pandey SK. Distribution Pattern and Management Strategy of Invasive Weed Parthenium *hysterophorus* L. in Gorakhpur, India. Asian J Biol Life Sci. 2023;12(1):138-43.