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Impact of *Parthenium hysterophorus* L. Invasion on Species Diversity of Cultivated Fields of Bilaspur (C.G.) India

Preeti Kumari, Pankaj K. Sahu, Madhu Y. Soni, Poonam Awasthi

Department of Botany, Dr. C.V. Raman University, Bilaspur (C.G.), India
Email: sahu.pankaj1@gmail.com

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Abstract

In present study invasion of *Parthenium hysterophorus* L. and its impacts on agriculture fields will be done in different cultivated crops in Bilaspur. The present work deals with diversity and distribution of weeds species in cultivated fields of Bilaspur C.G. A total number of 28 species under 27 genera and 16 families was distributed in three study sites (Koni, Sakri & Kota) of cultivated fields in Bilaspur C.G. These study sites were located in different altitudinal zones responding different conditions in the this study. The number of species per sites ranged from 13 to 24. In the Sakri, number of species was ranged from 17 to 27, and the relative density of plant species ranged between 0.77 (*Heteropogon contortus*, *Solanum surratense*, *Vernonia cinneria* and *Leucas aspera*) and 22.92 (*Parthenium hysterophorus*). In the Kota, number of species was ranged from 14 to 28, and the relative density of plant species ranged between 0.85 (*Ageratum conyzoides*, *Heteropogon contortus*, *Triticum aestivum*) and 29.06 (*Zea mays*) and 30.91 (*Parthenium hysterophorus*). In the Agriculture field, number of species was ranged from 15 to 28, and the relative density of plant species ranged between 0.58 (*Leucas aspera*) and 26.23 (*Triticum aestivum*). Present work will give the information that weeds are harmful to herbs, crops and medicinal plants. *Parthenium* weed can suppress and crowd out other weed species, and could form a single dominant population in the invasion area, causing serious threat to plant community biological diversity.

Keywords

***Parthenium*, Invasion, Species Diversity, Crops, Bilaspur**

1. Introduction

Invasive alien species are a serious implement to conservation and use of global biodiversity [1]. *Parthenium*

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hysterophorus, *Eichornia crassipes* and *Lantana camara* are among major IAS yet identified in Ethiopia [2]. *Parthenium hysterophorus* L. (Congress Grass) (here after referred as *Parthenium*) belongs to the family Asteraceae. *Parthenium* was introduced into Asia, Africa and Oceania with cereal and grass seed shipment from America during the 1950s [3]. *Parthenium* spreads easily through trade as contaminants of grain and other crop products by means of farm machineries [4]. In tropical and subtropical areas of the Indian, African and Australian continent, there is increasing concern on these adverse effects on human health, livestock, agriculture productivity and biodiversity [5]. Manual cutting results in rapid regeneration, which is quickly followed by flowering with abundant seed production [6].

The weed looks similar to other introduced weeds from the same family including seedlings of cobbler's pegs, leaves of *Artemisia* spp., flowers of bishop's weed *Ammi majus* and *Conium maculatum* and *Ambrosia* sp. [7]. In present study, work was done on impact of Parthenium, on species diversity, composition, agriculture in different cultivated crops of Bilaspur, C.G.

2. Materials & Methods

2.1. Study Area

The study was carried out in three study sites (Koni, Sakri & Kota) of cultivated fields of Bilaspur Chhattisgarh. The area experiences a typical monsoon climate, with three distinct seasons: summer from March-June, rainy monsoon period from July-October and winter from November-February. Bilaspur is situated between 17˚ to 23.7˚ north latitude and 8.40˚ to 83.38˚ east longitude. The climate is mainly tropical, humid and sub-humid. The average annual rainfall of the region is around 1400 mm and about 90% to 95% of this amount is received during south-west monsoon season (June-October). The atmospheric humidity is very high (>90%) during monsoon months and starts decreasing from October onwards and reaches as low as 15% - 20% during peak summer months. The soils of Chhattisgarh vary considerably in the three agro-climatic zones.

2.2. Topography and Soil

The landscape of the Bilaspur represents a complex of geological structure. This zone has a landscape whose physical property ranges from flat to gentle slope and hilly. Study areas are highly populated, rapidly urbanizing as industrial and market development centers. Productive agricultural land is rapidly being converted into housing areas in both study sites. The soils are generally lateritic, nutrient-poor and characterized by excessive amounts of iron oxide. In the present study area alluvial soils are found along the streams and rivers. The rock types are schist and gneisses with granite intrusion, sandstones, shales, limestone, basaltic lava and laterite with bauxite.

2.3. Data Collection

The study was carried out in 3 different sites of Bilaspur Chhattisgarh. The area experiences a typical monsoon climate, with three distinct seasons: summer from March-June, rainy monsoon period from July-October and winter from November-February. The soils are generally lateritic, nutrient-poor and characterized by excessive amounts of iron oxide. In the present study area alluvial soils are found along the streams and rivers. Field experiments were conducted to assess the impact of *Parthenium* weed (*Parthenium hysterophorus* L.) on species diversity of herbs and ground vegetation in cropped area of, Kota, Koni and Sakri sites in Bilaspur District, during 2013-2014. The samples were taken at the interval of 3 km. A total of 90 quadrats in each 3 sample sites (Kota, Sakri and Koni), thirty sample quadrats were taken from each major site. Each measuring 1 m × 1 m (1 m^2) sample quadrate was laid to assess the impact of *Parthenium* on aboveground herbaceous vegetation cover in the study area. Weeds species and herbaceous species were identified with help of Herbarium and local flora of state. The data on species diversity were analyzed for density and frequency [8]. The importance value index (IVI) was determined as the sum of relative frequency, and relative density [9]. Relative frequency and relative density relative were determined following Phillips [10].

3. Observation & Results

The total of 25, 26 and 28 species was recorded in Koni, Sakri & Kota sites, respectively. There were less spe-

cies in the invaded areas (23, respectively) than in the non-invaded areas (29, respectively) in 3 sites. Most common species found were *Achyranthes aspera*, *Ageratum conyzoides*, *Allium cepa*, *Argemone mexicana*, *Cajanus cajans*, *Cynadon dactylon*, *Dolichous*, *Tridax procumbans*, *Triticum aestivum*, *Xanthium*, *Zea mays* etc. in all studied areas. In all 3 sites some extra species were found in non-invaded areas like *Alternanthera*, *Blumea*, *Borreria*, *Commellina*, and *Vernonia* etc. Significant decreased in species richness found from *Parthenium* non-invaded to invaded areas. The species richness decreased on increase of *Parthenium* density in all study areas.

A total number of 28 species under 27 genera and 16 families distributed in three major study sites of cultivated fields of Bilaspur C.G. These study sites were located in different altitudinal zones responding digfferent condition in study sites, the number of species per sites ranged from 13 (KT4) to 24 (SK1). In the Agriculture field, number of species were ranged from 15 to 28, and the relative density of plant species ranged between 0.58 (*Leucas aspera*) and 26.23 (*Triticum aestivum*). The relative density of most of weeds in cultivated fields were 2.86 (18 species) and RD lower than 2 were observed in (11 species). In accordance with the variation in frequency/relative frequency & density relative density, the IVI values varied from 2.91 to 35.60. There were 9 species with IVI lower than 4 (**Table 1**, **Table 2**).

In the Sakri, number of species were ranged from 17 to 27, and the relative density of plant species ranged between 0.77 (*Heteropogon contortus*, *Solanum surratense*, *Vernonia cinneria* and *Leucas aspera*) aspera and 22.92 (*Parthenium hysterophorus*). The relative density of weeds of cultivated fields were 0.81 (7 species) and there were RD lower than 1 (8 species). In accordance with the variation in frequency/relative frequency & density or relative density, the IVI values varied from 2.07 to 35.42. There were 12 species with IVI lower than 10 (**Table 3**, **Table 4**).

In the Kota, number of species were ranged from 14 to 28, and the relative density of plant species ranged between 0.85 (*Ageratum conyzoides*, *Heteropogon contortus*, *Triticum aestivum*) and 29.06 (*Zea mays*) and 30.91 (*Parthenium hysterophorus*). The relative density of weeds of cultivated fields were 0.81 - 0.97 (5 species) and there were RD lower than 2 (10 species). In accordance with the variation in frequency/relative frequency & density relative density, the IVI values varied from 3.98 to 35.00. There were 11 species with IVI lower than 5 (**Table 5**, **Table 6**).

There were 3 major sites studied Koni, Sakari & Kota at Bilaspur. These sites shows the diverse and distribution pattern in frequency, density weeds species in *Parthenium* invaded and non invaded sites of Bilaspur. The gradual increase of *Parthenium* coverage towards the core of Agriculture areas and perennial barren and wastelands was found from the spatial observation and frequency distribution of site survey, in all study areas. Similarly, the gradual increase of *Parthenium* cover was found up to frequency class (50% - 100%). The invasion found increasing towards the semi-urbanized areas, agricultural lands and margin of forest areas.

4. Discussion

The dominant weeds were found in invaded sites of *Parthenium* (*Achyranthes aspera*, *Argemone mexicana*, *Tridax procumbans Cynodon dactylon*, *Dichanthium annulatum Allium cepa*, *Zea mays*, *Dichanthium annulatum*) while in non-invaded sites dominant species were *Triticum aestivum*, *Tridax procumbans Dolichos lablab*, *Achyranthes aspera Ageratum conyzoides Allium cepa* and *Dichanthium annulatum* while less dominant were *Xanthium strumarium*, *Borreria stricta and Blumea* sp. in study sites of cultivated crops of Bilaspur C.G. The similarity indices between *Parthenium* non-invaded and invaded areas of both study areas were found high. The high similarity value between *Parthenium* non-invaded and invaded areas of all study sites indicated that there is no radical change in species composition within the area.

Kohli *et al.* [11] reported a decline in species richness from 25 to 12 from *Parthenium* non-invaded site to high invaded site of Lower Himalaya (India). In present work the species diversity were observed from 28 (Non invaded site) to 13 (Invaded site). Similarly, Adkins and Sowerby [12] experimentally proved that *Parthenium* has allelopathic effect on its root and shoot leachates and thus has the ability to reduce the growth and germination of numerous associated species. The *Xanthium*, *Achyranthes*, *Tridex* might have strong association or competitive vigour with *Parthenium*; hence it was present only in *Parthenium* invaded area. But, *Ageratum*, *Borreria*, *Allium cepa*, *Cajans*, *Digitaria ciliaris*, *Cynadon*, *Dolichous*, *Triticum*, *Zea mays* were negatively affected by *Parthenium* invasion. The dominant weeds were found in invaded sites of *Parthenium* (*Zea mays*, *Cynodon dactylon*) while co-dominant species were *Digitalia ciliaris*, *Dolichos lablab* and in non-invaded sites dominant species was *Triticum aestivum* while less dominant one was *Leucas aspera* in agriculture field of Bilaspur C.G.

Table 1. Representing the RD of invaded and non-invaded sites of *Parthenium hysterophorus* in Agriculture field (Koni).

	Parthenium Non-invaded					*Parthenium* Invaded				
	KN1	KN2	KN3	KN4	KN5	KN1	KN2	KN3	KN4	KN5
Achyranthes aspera	3.49	3.66	3.28	3.94	8.57		2.00	4.46	4.17	7.41
Anagallis arvensis	8.72	3.05	5.74		2.86					
Ageratum conyzoides	2.91	3.05	5.74	3.15	2.86	6.67	4.00	2.68	4.17	3.70
Allium cepa				3.94	2.86	6.67	11.00	16.96	12.50	7.41
Alternanthera paronychioides	4.65	1.83			2.86					
Argemone mexicana	8.72	4.27	6.56	4.72	2.86	3.33	6.00	2.68	1.39	3.70
Blumea lacera		1.22			2.86					
Borreria stricta	0.58				2.86					
Cajanus cajan	5.81		3.28	6.30	5.71	6.67	11.00	8.93	6.94	7.41
Chrysophogon aciculatus	4.65	5.49	4.10		2.86	6.67	4.00	3.57	2.78	3.70
Commelina benghalensis					2.86					
Cynodon dactylon	9.88	6.71	3.28	5.51	5.71	6.67	3.00	7.14	12.50	3.70
Desmodium triflorum	1.74	4.88		4.72	2.86	6.67	4.00	3.57	1.39	3.70
Dichanthium annulatum	5.81	6.71	11.48	3.94	2.86	3.33	2.00	3.57	5.56	7.41
Dichanthium aristatum							3.00	2.68	2.78	3.70
Digitaria ciliaris	2.91	3.05	5.74		5.71	3.33	4.00	6.25	4.17	7.41
Dolichos lablab	6.40	7.32	2.46	3.94	2.86	6.67	11.00	3.57	2.78	3.70
Heteropogon contortus	7.56	9.15		5.51	2.86					
Leucas aspera	**0.58**				2.86					
Lindernia crustata	1.16	6.71	9.02	3.94	5.71					
Parthenium hysterophorus						6.67	9.00	16.96	18.06	11.11
Raphanus sativus	6.40	1.83	4.92	7.09	2.86	6.67	4.00	2.68	4.17	3.70
Solanum surratense	2.91	6.10	3.28	4.72	2.86	3.33	3.00	0.89	1.39	3.70
Tridax procumbans	1.16	3.66	4.92	2.36	5.71	10.00				
Triticum aestivum	10.47	12.20	26.23	21.26	5.71	6.67				
Vernonia cinneria		1.83			2.86					
Xanthium strumarium	2.33	5.49		3.15	5.71	3.33	9.00	4.46	4.17	7.41
Zea mays	1.16	1.83		11.81	2.86	6.67	10.00	8.93	11.11	11.11

Table 2. Representing the IVI of invaded and non-invaded of *Parthenium hysterophorus* in study sites of agriculture fields (Koni).

Name of plant species	*Parthenium* Non-invaded Sites					*Parthenium* Invaded Sites				
	KN1	KN2	KN3	KN4	KN5	KN1	KN2	KN3	KN4	KN5
Achyranthes aspera	10.47	6.04	9.53	6.97	12.12		7.71	7.32	8.01	11.41
Anagallis arvensis	15.70	7.81	8.86		4.28					
Ageratum conyzoides	7.56	5.43	11.99	9.21	4.28	10.04	6.86	8.39	11.86	6.37
Allium cepa				10.00	4.28	15.66	16.71	25.54	20.19	22.07
Alternanthera paronychioides	9.30	4.21			4.98					
Argemone mexicana	15.70	11.41	12.81	10.79	4.28	5.58	11.71	5.54	5.24	7.70
Blumea lacera		3.60			5.69					
Borreria stricta	2.91				3.57					
Cajanus cajan	10.47		9.53	12.36	11.39	19.03	16.71	14.64	14.64	18.07
Chrysophogon aciculatus	9.30	12.63	7.22		3.57	10.04	9.71	9.29	6.62	9.04
Commelina benghalensis					4.28					
Cynodon dactylon	16.86	11.47	9.53	8.54	9.97	10.04	8.71	12.86	24.04	6.37
Desmodium triflorum	4.07	9.64		10.79	3.57	8.91	9.71	9.29	5.24	5.04
Dichanthium annulatum	10.47	11.47	20.85	10.00	4.98	4.46	7.71	9.29	9.40	10.07
Dichanthium aristatum							8.71	8.39	10.47	6.37
Digitaria ciliaris	7.56	7.81	15.11		9.26	4.46	9.71	14.82	8.01	16.74
Dolichos lablab	11.05	12.08	8.71	10.00	4.28	23.52	16.71	9.29	6.62	6.37
Heteropogon contortus	12.21	16.29		11.57	6.40					
Leucas aspera	2.91				3.57					
Lindernia crustata	5.81	13.85	18.39	10.00	7.84					
Parthenium hysterophorus						25.77	14.71	25.54	29.59	25.78
Raphanus sativus	11.05	4.21	14.29	13.15	4.98	12.28	9.71	8.39	8.01	7.70
Solanum surratense	5.23	10.86	6.40	10.79	4.28	6.70	8.71	3.75	5.24	5.04
Tridax procumbans	3.49	8.42	11.17	5.39	9.26	14.49				
Triticum aestivum	17.44	19.34	35.60	30.35	14.93	10.04				
Vernonia cinneria		6.59			3.57					
Xanthium strumarium	4.65	10.25		9.21	8.55	5.58	17.57	10.18	8.01	12.74
Zea mays	5.81	6.59		20.90	3.57	13.41	18.57	17.50	18.80	23.11

Table 3. Representing the RD of invaded and non-invaded sites of *Parthenium hysterophorus* in Sakri.

Name of species	*Parthenium* Non-invaded Sites					*Parthenium* Invaded Sites				
	SK1	SK2	SK3	SK4	SK5	SK1	SK2	SK3	SK4	SK5
Achyranthes aspera	1.61	3.48	5.38	5.13	8.64	6.15	3.85	3.70	4.17	3.57
Anagallis arvensis	1.61	0.87	1.54	2.56	2.47					
Ageratum conyzoides	0.81	3.48	2.31	5.13	3.70	6.15	3.85	1.85	4.17	2.38
Allium cepa	2.42	6.09	9.23		6.17	15.38	15.38	12.96	10.42	8.33
Alternanthera paronychioides		2.61		8.55	3.70					
Argemone mexicana	5.65	0.87	3.08	0.85	4.94	3.08	1.92	1.85	2.08	1.19
Blumea lacera	1.61		1.54	2.56						
Borreria stricta	0.81	2.61	3.08	4.27	4.94					
Cajanus cajan	8.87	1.74	3.08		3.70	3.08	3.85	1.85	4.17	7.14
Chrysophogon aciculatus	0.81	9.57	3.08	5.98	2.47	4.62	1.92	1.85	2.08	1.19
Commelina benghalensis		2.61	3.85	1.71						
Cynodon dactylon	8.87	11.30	12.31	8.55	6.17	13.85	7.69	16.67	8.33	5.95
Desmodium triflorum	1.61	1.74		1.71	4.94	7.69	1.92	3.70	4.17	1.19
Dichanthium annulatum	0.81	2.61	3.08	0.85	4.94	7.69	5.77	1.85	4.17	4.76
Dichanthium aristatum						1.54	3.85	3.70	2.08	3.57
Digitaria ciliaris	4.84	0.87	1.54	1.71	2.47	3.08	3.85	3.70	4.17	2.38
Dolichos lablab	10.48	9.57	16.15	13.68	12.35	4.62	1.92	3.70	8.33	15.48
Heteropogon contortus	0.81	2.61	0.77	0.85	2.47					
Leucas aspera	0.81	0.87	0.77	3.42						
Lindernia crustata	1.61			2.56	3.70					
Parthenium hysterophorus						10.77	17.31	22.22	22.92	15.48
Raphanus sativus	6.45	6.96	1.54	1.71	3.70	4.62	1.92	3.70	2.08	4.76
Solanum surratense	3.23	1.74	0.77	4.27	4.94	1.54	5.77	1.85	4.17	2.38
Tridax procumbans	14.52	6.96	7.69	2.56	6.17					
Triticum aestivum	10.48	17.39	9.23	6.84	2.47					
Vernonia cinneria	2.42	1.74	0.77	1.71	1.23					
Xanthium strumarium	0.81	0.00	3.85	1.71	0.00	3.08	5.77	3.70	4.17	5.95
Zea mays	8.06	1.74	5.38	11.11	3.70	3.08	13.46	11.11	8.33	14.29

Table 4. Representing the IVI of invaded and non-invaded of *Parthenium hysterophorus* in study sites of Sakri.

Name of plant species	*Parthenium* Non-invaded Sites					*Parthenium* Invaded Sites				
	SK1	SK2	SK3	SK4	SK5	SK1	SK2	SK3	SK4	SK5
Achyranthes aspera	4.18	8.61	7.98	12.82	14.70	10.00	7.85	7.41	8.33	7.14
Anagallis arvensis	4.18	3.43	2.84	5.13	5.50					
Ageratum conyzoides	3.37	11.17	3.61	10.26	6.73	10.00	7.85	5.56	12.50	5.95
Allium cepa	7.55	11.22	13.13	0.00	12.23	26.92	27.38	24.07	22.92	15.48
Alternanthera paronychioides	0.00	5.17	0.00	16.24	6.73					
Argemone mexicana	10.77	3.43	4.38	3.42	11.00	6.92	5.92	5.56	6.25	4.76
Blumea lacera	4.18	0.00	2.84	5.13						
Borreria stricta	3.37	5.17	5.67	9.40	11.00					
Cajanus cajan	16.56	4.30	5.67		6.73	6.92	7.85	5.56	8.33	14.29
Chrysophogon aciculatus	3.37	17.26	5.67	13.68	8.53	12.31	5.92	5.56	6.25	4.76
Commelina benghalensis		5.17	5.14	6.84	0.00					
Cynodon dactylon	14.00	19.00	16.20	16.24	12.23	25.38	15.69	24.07	16.67	13.10
Desmodium triflorum	4.18	4.30	0.00	4.27	7.97	15.38	5.92	7.41	8.33	4.76
Dichanthium annulatum	3.37	7.74	4.38	3.42	11.00	15.38	13.77	5.56	8.33	11.90
Dichanthium aristatum						5.38	7.85	7.41	6.25	7.14
Digitaria ciliaris	9.97	3.43	2.84	4.27	5.50	6.92	7.85	11.11	8.33	5.95
Dolichous lablab	18.18	17.26	43.43	18.80	21.44	8.46	5.92	11.11	12.50	26.19
Heteropogon contortus	3.37	5.17	2.07	3.42	5.50					
Leucas aspera	3.37	3.43	2.07	5.98	0.00					
Lindernia crustata	4.18	0.00	0.00	5.13	9.76					
Parthenium hysterophorus						18.46	25.31	33.33	35.42	26.19
Raphanus sativus	11.58	12.08	2.84	4.27	6.73	12.31	5.92	7.41	6.25	8.33
Solanum surratense	5.79	4.30	2.07	9.40	7.97	5.38	9.77	5.56	8.33	5.95
Tridax procumbans	22.21	14.65	20.68	5.13	9.20					
Triticum aestivum	18.18	25.08	19.62	11.97	5.50					
Vernonia cinneria	4.98	4.30	2.07	4.27	4.26					
Xanthium strumarium	3.37	0.00	10.34	4.27	0.00	6.92	13.77	11.11	8.33	13.10
Zea mays	15.76	4.30	14.48	16.24	9.76	6.92	25.46	22.22	16.67	25.00

Table 5. Representing the RD of invaded and non-invaded sites of *Parthenium hysterophorus* in Kota.

Name of species	*Parthenium* Non-invaded Sites					*Parthenium* Invaded Sites				
	KT1	KT2	KT3	KT4	KT5	KT1	KT2	KT3	KT4	KT5
Achyranthes aspera	6.10	5.75	5.83	9.40	6.14	4.44	10.71	3.45	10.87	3.64
Anagallis arvensis	3.66	1.15	1.94	3.42	4.39					
Ageratum conyzoides	7.32	5.75	8.74	0.85	4.39	8.89	3.57	6.90	0.00	3.64
Allium cepa	9.76	1.15	9.71	2.56	13.16	0.00	3.57	3.45	10.87	5.45
Alternanthera paronychioides	4.88	3.45	5.83	3.42	1.75					
Argemone mexicana	2.44	4.60	0.97	1.71	1.75	4.44	0.00	3.45	6.52	5.45
Blumea lacera	1.22	2.30	7.77	1.71	2.63					
Borreria stricta	6.10	0.00	0.00	3.42	4.39					
Cajanus cajan	4.88	10.34	2.91	0.00	0.88	4.44	1.79	1.72	2.17	1.82
Chrysophogon aciculatus	1.22	1.15	0.00	5.13	2.63	0.00	5.36	5.17	13.04	1.82
Commelina benghalensis	4.88	0.00	4.85	0.00	1.75					
Cynodon dactylon	4.88	4.60	1.94	3.42	1.75	4.44	1.79	1.72	8.70	9.09
Desmodium triflorum	8.54	10.34	0.97	2.56	2.63	0.00	3.57	6.90	4.35	3.64
Dichanthium annulatum	2.44	5.75	4.85	1.71	2.63	2.22	10.71	1.72	10.87	1.82
Dichanthium aristatum					3.51	11.11	1.79	1.72	0.00	7.27
Digitaria ciliaris	2.44	6.90	0.00	4.27	3.51	11.11	0.00	6.90	8.70	1.82
Dolichos lablab	3.66	2.30	1.94	2.56	4.39	2.22	5.36	3.45	0.00	0.00
Heteropogon contortus	1.22	6.90	0.97	0.85	3.51					
Leucas aspera	2.44	0.00	3.88	2.56	3.51					
Lindernia crustata	2.44	4.60	2.91	2.56	6.14					
Parthenium hysterophorus					2.63	8.89	10.71	10.34	6.52	30.91
Raphanus sativus	1.22	2.30	0.00	1.71	5.26	2.22	0.00	0.00	4.35	5.45
Solanum surratense	1.22	3.45	9.71	4.27	3.51	4.44	16.07	13.79	0.00	1.82
Tridax procumbans	4.88	3.45	0.00	5.98	2.63	4.44	7.14	1.72	4.35	1.82
Triticum aestivum	2.44	0.00	6.80	0.85	1.75	6.67	0.00	12.07	4.35	3.64
Vernonia cinneria	2.44	5.75	4.85	1.71	8.77					
Xanthium strumarium	2.44	0.00	3.88	4.27	10.0	0.00	5.36	8.62	0.00	5.45
Zea mays	4.88	8.05	8.74	29.06		20.00	12.50	6.90	4.35	5.45

Table 6. Representing the IVI of invaded and non-invaded of *Parthenium hysterophorus* in study sites of Kota.

Name of plant species	*Parthenium* Non-invaded Sites					*Parthenium* Invaded Sites				
	KT1	KT2	KT3	KT4	KT5	KT1	KT2	KT3	KT4	KT5
Achyranthes aspera	12.35	13.15	15.20	18.78	11.14	9.44	20.24	11.14	19.96	10.78
Anagallis arvensis	6.78	4.85	5.07	6.54	9.39					
Ageratum conyzoides	13.57	9.45	18.11	3.98	6.89	18.89	8.33	10.74		7.21
Allium cepa	16.01	4.85	15.96	5.69	18.16	5.00	8.33	7.29	19.96	12.60
Alternanthera paronychioides	8.00	7.15	8.95	6.54	4.25					
Argemone mexicana	8.69	8.30	4.10	4.83	6.75	9.44		11.14	11.07	12.60
Blumea lacera	4.34	6.00	14.02	4.83	7.63					
Borreria stricta	9.22			6.54	9.39					
Cajanus cajan	8.00	17.75	9.16		3.38	9.44	6.55	5.57	6.72	5.39
Chrysophogon aciculatus	4.34	4.85		11.38	7.63		10.12	12.86	22.13	5.39
Commelina benghalensis	8.00		11.10		4.25					
Cynodon dactylon	8.00	8.30	5.07	9.67	4.25	9.44	6.55	5.57	13.24	16.23
Desmodium triflorum	11.66	14.05	4.10	5.69	5.13		8.33	14.59	8.89	10.78
Dichanthium annulatum	5.56	9.45	11.10	4.83	7.63	7.22	20.24	5.57	19.96	5.39
Dichanthium aristatum						16.11	6.55	5.57		14.42
Digitaria ciliaris	5.56	10.60		7.40	6.01	16.11		14.59	17.79	5.39
Dolichous lablab	6.78	6.00	5.07	5.69	8.51	7.22	10.12	7.29		
Heteropogon contortus	4.34	14.30	4.10	3.98	6.89					
Leucas aspera	8.69		7.01	5.69	6.01					
Lindernia crustata	5.56	8.30	6.04	5.69	6.01					
Parthenium hysterophorus						13.89	20.24	18.04	11.07	41.62
Raphanus sativus	4.34	6.00		4.83	11.14	7.22			13.44	12.60
Solanum surratense	4.34	7.15	15.96	7.40	5.13	9.44	25.60	21.49		5.39
Tridax procumbans	8.00	7.15		9.11	10.26	9.44	11.90	5.57	8.89	5.39
Triticum aestivum	5.56		9.92	3.98	6.01	16.67	0.00	15.92	13.44	7.21
Vernonia cinneria	5.56	13.15	7.98	4.83	7.63					
Xanthium strumarium	5.56		10.13	13.65	4.25		14.88	12.47		9.03
Zea mays	11.13	19.16	11.86	38.43	16.27	35.00	22.02	14.59	13.44	12.60

Displacement by direct competition reduced structural diversity, and increased biomass production and disruption of the prevailing vegetation dynamics [13]. Timsina [14] reported *Trifolium repens*, *Imperata* sp., *Chrysopogan aciculatus*, *Sporobolus* sp. and *Dactyloctenium aegypticum* as affected by *Parthenium* invasion and abundance of palatable species decreased with possible impact on fodder supply. The frequency of *Triticum astevim* increased from non invaded plots at Sakari and the frequency was nearly equal at invaded and non-invaded plots at Koni. Similarly, the nearly equal frequency of *Allium cepa Dollichous*, *Cynadon* at invaded and non-invaded plots indicates the resistance of *Argemon*, *Desmodium* against *Parthenium* invasion. There were no significant differences in frequency of *Chrysopogan aciculatus*, *Cynodon dactylon*, *Mimosa pudica*, *Paspalidium flavidum*, *Paspalum scrobiculatum*, *Scoparia dulcis*, *Setaria gauca*, *Solanum surattense* and *Sida rhombifolia* on *Parthenium* invasion, which meant that those species might compete with *Parthenium*. Timsina [14] reports similar abundance of *Euphorbia hirta* and *Cassia tora* in areas with different levels of *Parthenium* invasion. As reported by Mahadevappa, *et al*. [15] *Parthenium* weed caused up to 90% decline in forage production. The survey was conducted in India. The species like *Cassia sericea*, *Cassia tora*, *Cassia auriculata*, *Croton bonplandianum*, *Amaranthus spinosus*, *Tephrosia purpurea*, *Hyptis suaveolens*, *Sida spinosa* and *Mirabilis jalapa* suppressed *Parthenium* in natural habitats shown by [16]. In Ethiopia it showed that about 93.6%, 90.8% and 77.7% of variation in density of broad leaved, grass and sedges were respectively accounted for the density of parthenium [17]. *Partenium hysterophorus* L., commonly known as congress grass, feverfew, ragweed parthenium or white top is a noxious weed native to tropical America. It has now naturalized in several tropical and subtropical parts of the world [18] [19]. The invasion is more favoured by the human activities than the allelopathic nature and reproductive efficiency of weeds invasion. Many aggressive invasive plants like *Ageratum mexicana*, *Lantana camara* and *Parthenium hysterophorum* are well established in the lower Himalaya due to suitable environmental conditions for their growth as similar to their native range [18] [20]. Due to the higher level of invasion which was found gradually decreased the human interference from industrial areas to highly populated inhabitancy areas, high traffic highway road sides, industrial link roads, rangelands, semi-urban areas, minor highways, link roads between urban areas and village, agricultural lands of urban areas, these areas were found under the threat of high invasion unless proper management was undertaken.

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Abbreviations

IVI = Importance Value Index
RD = Relative Density
RF = Relative Frequency
KT = Kota site, KT1-5 SK1-5 for five sites each invaded and non invaded sites
SK = Sakri, SK1-5 for five sites each invaded and non invaded sites
KN = Koni, KN1-5 SK1-5 for five sites each invaded and non invaded sites

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