Species Composition And Shoot Biomass Production In Parthenium Dominated Abandoned Fallowland.

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Abstract: The present study was conducted in J.P.University campus, Chapra, Bihar,India to record the species composition and production of shoot biomass of Partheniumhysterophorus L. invaded vegetation development in abandoned cropland. A total number of 13 herbaceous species were recorded. In addition to Parthenium other herbaceous plant species were Dicanthiumannulatum, Oxalis corniculata, Cynodon dactylon, Daucyloeniumaegyptium, Tridax procumbens, Cyperus rotundus, Digitaria setigera, Phyllanthus niruri, Euliseinindica, Evolvulusalsinoides, Crotonsparslorus and Alysicarpus monolifer. Phytosociological characteristics such as frequency, density, abundance, live shoot biomass, relative frequency, relative density and relative dominance were determined quantitatively and qualitatively. In this study Parthenium was the most dominant species having highest IVI values (106.29). The co-dominant species was Dicanthium annulatum (IVI= 45.68). Species richness, equitability and diversity values are lower than the values reported for tropical grassland vegetation of India. Shoot biomass values were higher than the Indian grasslands. Thus, Parthenium showed aggressiveness and dominance in the newly developed vegetation. Parthenium is affecting the normal process of succession on abandoned agricultural land by decreasing the species richness and plant diversity. Thus eradication of Parthenium is essential to accelerate the normal process of vegetation development and shoot biomass produced by Parthenium may be utilized in other beneficial purposes.

Keywords: Abandoned agricultural land, Dominant species, Parthenium, Species Composition, Vegetation.

I. Introduction

Partheniumhysterophorus L. is an annual herbaceous prolific weed belonging to Asteraceae family. Parthenium came to India under US PL – 480 scheme and invaded all parts of India [23], [45] for the first time reported its existence in India. Partheniumis a native weed of Mexico and has been widely distributed to the different countries such as Australia, India, China, Kenya, Ethiopia, Nepal etc. through contaminated grains and farm machineries [30]. It has been widely distributed and created problems in countries like Kenya, Taiwan, India, west Indies, Nepal etc. [43]; [41]; [61]; [47]; [7]; [13]. This weed has achieved major status in India and Australia in the last three decades [35]; [16]; [31]; [24]; [7]; [15] has reported about two million hectares of land in India has been invaded by Parthenium. The presence of Parthenium have the drastic effect on the agricultural crops and also causes health hazards in human beings and affects ecosystem and biodiversity [1]; [35]; [29]. Parthenium is an aggressive colonizer, production of large amount of seeds; shows allelopathic effects; induces changes in the physical, chemical and biological properties of soil; replaces palatable grasses in rangelands and its manual removal is difficult [57]; [39]; [61]; [36]; [37]; [4]; [5]; [53]; [55]; [6]; [7]; [62]; [27]; [2]; [3]; [63]; [38]; [57] have showed that Parthenium was the most major problem in rangeland and cropland in the Eastern Ethiopia. Parthenium fastly grows and is comfortable on alkaline to neutral clay soils [10], [34] have reported that the spread of seeds and their ability to remain viable in the soil for many years pose one of the most complex problems for control and this fact makes eradication difficult for many seed producing Parthenium.

In the human beings it causes various types of allergies particularly through pollen grain like contact dermatitis, hay fever, asthma and bronchitis [35]; [64]. [54] have mentioned that pesticides like atrazine, 2,4-D metribuzin, paraquat, trifluralin and diphenamidonot show any effect. Parthenium secretes certain allelochemicals such as: phenolic acids, caffeic acid, vanillic acid, ferulic acid, chlorogenic acid, paracauamic acid, para hydroxy benzoic acid [21]; [11], and other important chemicals such as pseudougonaolides, parthenin, anhydroparthenin, amboasins, cronopilin and damsin which have adverse effect on the growth of plants which grow in its vicinity. [25] reported that secondary metabolites are released through volatilization, leaching, root exudation and decomposition of plant residues in the soil. [14] have reported two life cycles in one year in Parthenium from March to June and from July to November in North-Western Indian Himalayas (H.P.). They produce enormous number of seed which are very small in size and also light in weight and can survive as seed bank in soil for years. Parthenium is an annual plant with a deep tap-root and an erect much-branched stem. Usually grows 1-2 m. tall. Mature stems are greenish and longitudinally grooved, covered with small stiff
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hairs (trichomes). Leaves are simple, pale green, lobed, sessile, irregularly dissected. The number of leaves per plant is 6 to 55. The flowers are arranged in capitulum, creamy white in colour, borne in profusion at the tips of the stem. Small flower heads are arranged in clusters and its colour changes to light brown, when seeds are mature. Flowering can occur at any time of the year, but is most common during the rainy season. Each flower contains five seeds, which are wedge-shaped, black, 2 mm long with thin white scales.

Parthenium commonly called as congress grass or carrot weed, feverfew, ragweed Parthenium mand white top. In India, it is locally known as Gajar Ghans. It contains special characters such as: high germination ability, large seed production capacities, high survival rate, extreme adaptability in different habitats, easy dispersal of seeds, high allelopathic impact and completes life-cycles within four weeks [49]; [50]; [51].

In Bihar particularly at Chapra no ecological study on Parthenium invaded vegetation has been done. It is invading fallowland, cropland, wasteland, roadsides etc. on large scale. Nine years ago in about 240 ha of cropland, J.P. University campus Chapra was established. In abandoned cropland of this University campus natural herbaceous vegetation development started. But at the same time invasion of P. hysterophorus occupied the whole area. Thus the natural process of plant succession was badly affected by invasion of P. hysterophorus. The whole area is occupied by this aggressive exotic species. The main aim of this study was to analyse the species composition and shoot biomass estimation of Parthenium in the abandoned cropland. To know the formation of plant community associated with Parthenium is essential. How much shoot biomass is produced by Parthenium that can be useful in other purposes. Therefore, the present study was conducted in abandoned cropland to know the effect of Parthenium species composition of early vegetation developed in fallowland and level of production of shoot biomass by Parthenium which can be used in other beneficial purposes.

II. Materials and methods

The species composition and shoot biomass estimation study was conducted in J.P. University Chapra campus in the month of September, 2015. The university campus was established about nine years ago in about 240 ha land where earlier cropping was done. In this fallowland herbaceous vegetation has developed but the invasive species Parthenium has invaded the campus on large scale. The study site is situated between 25° 36’ - 26° 15’ N latitude and 84° 25’ - 85° 15’ E longitude. The climate is hot and dry. Annual rainfall normally varies from 66 to 126 cm in rainy season. The maximum and minimum temperature ranges from 60°c to 45°c. The relative humidity ranges from 39 to 90 per cent in the months of May and December, respectively. Sampling was done for the study of vegetation invaded by Parthenium. Randomly ten quadrates of 50 X 50 cm² sizes were placed in the vegetation. All herbaceous plants at the soil surface were harvested. Harvested samples of each quadrate were kept in separate polyethylene bags. Samples were brought to the laboratory and samples of each quadrat were separated species wise and their numbers were counted. We took fresh weight through the electronic balance and were oven-dried at 80°c for 24 hrs. and again dry weight was taken.

The following quantitative and qualitative analyses of plants were done: frequency, density, abundance, relative frequency, relative density, relative dominance, importance value index, species richness, species diversity and equitability.

Frequency, density and abundance were calculated following the formula proposed by [8] as given below:

\[
\text{Frequency(\%)} = \frac{\text{Total no of quadrates in which species occurred}}{\text{Total no of quadrates studied}} \times 100
\]

\[
\text{Density} = \frac{\text{Total no of individuals of species}}{\text{Total no of quadrates studied}}
\]

\[
\text{Abundance} = \frac{\text{Total no of individuals of the species}}{\text{Total no of quadrates in which species occurred}}
\]

Relative frequency, relative density and relative dominance were determined following the formula of [42] as given below:

\[
\text{Relative frequency (\%)} = \frac{\text{No. of occurrence of the species}}{\text{No. of occurrence of all species}} \times 100
\]

\[
\text{Relative density (\%)} = \frac{\text{No. of individuals of the species}}{\text{Total no of individuals of all species}} \times 100
\]

\[
\text{Relative dominance (\%)} = \frac{\text{Total shoot biomass of the species}}{\text{Total shoot biomass of all species}} \times 100
\]

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The Importance Value Index (IVI) was the sum of the relative frequency (RF), relative density (RD) and relative dominance (RDo) \[9, 42\].

Species richness was calculated following the formula \[32\]:

\[
S - 1 \quad \frac{\ln N}{N}
\]

Where, \( S \) = Total no. of species in the given stand or sample,
\( N \) = Total shoot biomass of all the species in that sample.

Species diversity was calculated following the formula as \[48\]:

\[
H = \sum_{i=1}^{S} \frac{N_i}{N} \log_2 \left( \frac{N_i}{N} \right)
\]

Where, \( N_i \) was the total shoot biomass of individuals of species, \( i \) and \( N \) was the total shoot biomass of all species in that site.

Equitability (EC) was calculated following the formula \[32\]:

\[
EC = \frac{S}{\ln(n_{max} - n_{min})}
\]

Where, \( S \) is the total no. of species in the site; and \( n_i \) and \( n_s \), the shoot biomass values of most and least important species, respectively.

### III. Results

There was a very high infestation of *P. hysterophorus* in the present study site. A total number of 13 plant species were recorded, in which *P. hysterophorus* is the most dominant species. Other species were *Dicanthium annulatum*, *Oxalis corniculata*, *Cynodon dactylon*, *Dactyloetenium aegyptium*, *Tridax procumbens*, *Cyperus rotundus*, *Digitaria setigera*, *Phyllanthus niruri*, *Eleusine indica*, *Evolvulus alsinoides*, *Croton sparsiflorus* and *Alysicarpus monolifer*.

**Frequency** - The frequency value for *Parthenium* was 100% . The frequency values of other species ranged from 10 to 100%. It was minimum (10%) for *C. sparsiflorus* and *A. monolifer* where as it was maximum (100%) for *O. corniculata*.

**Density** - The density value for *Parthenium* was 188.4 m\(^{-2}\). The density values of other species ranged from 0.4 to 402.4 m\(^{-2}\). The minimum value (0.4 m\(^{-2}\)) was recorded for *C. sparsiflorus* and maximum value was 402.4 m\(^{-2}\) for *D. annulatum*.

**Abundance** - The abundance value for *Parthenium* was 188.4. The abundance values of other species ranged from 4 to 447.11. The minimum value 4 was recorded for *C. sparsiflorus* and maximum value was (447.11) for *D. annulatum*.

**Live Shoot Biomass** - The live shoot biomass value for *Parthenium* was 3205.32 gm\(^{-2}\). The biomass values for other species ranged from 1 to 330.72 gm\(^{-2}\). It was minimum 1 gm\(^{-2}\) for *A. monolifer* where as it was maximum value was 330.72 gm\(^{-2}\) for *D. annulatum*.

**Relative frequency** - The value for relative frequency of *Parthenium* was 14.70%. The relative frequency values of other species ranged from 1.47 to 14.70%. The minimum value 1.47% was recorded for *C. sparsiflorus* and *A. monolifer* where as the maximum value 14.70% was recorded for *O. corniculata*.

**Relative Density** - The relative density value for *Parthenium* was 11.31%. The relative density of other species ranged from 0.02 to 24.17%. The lowest value 0.02% was recorded for *C. sparsiflorus* and highest value was 24.17% for *D. annulatum*.

**Relative Dominance** - The relative dominance value for *Parthenium* was 80.28%. The relative dominance values of other species ranged from 0.2 to 8.28%. The minimum value 0.2% was recorded for *C. sparsiflorus* and *A. monolifer* where as the maximum value 8.28% was recorded for *D. annulatum*.

**Importance Value Index** - The IVI value for *Parthenium* was 106.29 . The IVI value of co-dominant species *D. annulatum* was 45.68 . Thus the community developed after nine years of abandonment of cropland infested with *Parthenium* was *Parthenium hysterophorus* - *Dicanthium annulatum* Community.
The species richness, species diversity and equitability values were recorded, respectively as 1.45, 0.19 and 1.61 for the study sites.

**Table 1.** Species composition and shoot biomass attributes of Parthenium invaded fallowland after nine years of abandonment.

<table>
<thead>
<tr>
<th>Name of Species</th>
<th>Frequency (%)</th>
<th>Density (m⁻²)</th>
<th>Abundance</th>
<th>Live Biomass (gm⁻²)</th>
<th>Shoot Biomass (gm⁻²)</th>
<th>RF (%)</th>
<th>RD (%)</th>
<th>RDo (%)</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parthenium hysterophorus</td>
<td>100</td>
<td>188.4</td>
<td>188.4</td>
<td>3205.32</td>
<td>14.70</td>
<td>11.34</td>
<td>80.28</td>
<td>106.29</td>
<td></td>
</tr>
<tr>
<td>Dicanthium annulatum</td>
<td>90</td>
<td>402.4</td>
<td>447.11</td>
<td>330.72</td>
<td>13.23</td>
<td>24.17</td>
<td>8.28</td>
<td>45.68</td>
<td></td>
</tr>
<tr>
<td>Oxalis corniculata</td>
<td>100</td>
<td>358.4</td>
<td>358.4</td>
<td>107.6</td>
<td>14.70</td>
<td>21.31</td>
<td>2.69</td>
<td>38.7</td>
<td></td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>90</td>
<td>279.2</td>
<td>310.22</td>
<td>127.92</td>
<td>13.23</td>
<td>16.77</td>
<td>3.20</td>
<td>33.2</td>
<td></td>
</tr>
<tr>
<td>Dactyloctenium maegyptium</td>
<td>60</td>
<td>142.8</td>
<td>238</td>
<td>67.24</td>
<td>8.82</td>
<td>8.57</td>
<td>1.68</td>
<td>19.07</td>
<td></td>
</tr>
<tr>
<td>Tridax procumbens</td>
<td>80</td>
<td>78.8</td>
<td>98.5</td>
<td>54.28</td>
<td>11.7</td>
<td>4.73</td>
<td>1.35</td>
<td>17.84</td>
<td></td>
</tr>
<tr>
<td>Cyperus rotundus</td>
<td>30</td>
<td>110.8</td>
<td>369.33</td>
<td>11.12</td>
<td>4.41</td>
<td>6.65</td>
<td>0.27</td>
<td>11.33</td>
<td></td>
</tr>
<tr>
<td>Digitaria setigera</td>
<td>20</td>
<td>72.4</td>
<td>362</td>
<td>62.44</td>
<td>2.94</td>
<td>4.34</td>
<td>1.56</td>
<td>8.84</td>
<td></td>
</tr>
<tr>
<td>Phyllanthus niruri</td>
<td>40</td>
<td>22.4</td>
<td>56</td>
<td>9.48</td>
<td>5.88</td>
<td>1.37</td>
<td>0.23</td>
<td>7.48</td>
<td></td>
</tr>
<tr>
<td>Eleusine indica</td>
<td>30</td>
<td>1.6</td>
<td>5.33</td>
<td>2.00</td>
<td>4.41</td>
<td>0.09</td>
<td>0.05</td>
<td>4.55</td>
<td></td>
</tr>
<tr>
<td>Evolvulus alpinoides</td>
<td>20</td>
<td>10</td>
<td>50</td>
<td>12</td>
<td>2.94</td>
<td>0.60</td>
<td>0.30</td>
<td>3.84</td>
<td></td>
</tr>
<tr>
<td>Croton sparsiflorus</td>
<td>10</td>
<td>0.4</td>
<td>4</td>
<td>1.12</td>
<td>1.47</td>
<td>0.02</td>
<td>0.02</td>
<td>1.53</td>
<td></td>
</tr>
<tr>
<td>Alysicarpus monilifer</td>
<td>10</td>
<td>0.8</td>
<td>8</td>
<td>1.00</td>
<td>1.47</td>
<td>0.04</td>
<td>0.02</td>
<td>1.51</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>680</td>
<td>1664.8</td>
<td>2491.69</td>
<td>3992.24</td>
<td>99.98</td>
<td>99.94</td>
<td>99.93</td>
<td>299.86</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species richness</th>
<th>Species diversity</th>
<th>Equitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.45</td>
<td>0.196</td>
<td>1.61</td>
</tr>
</tbody>
</table>

**IV. Discussion**

This study revealed that the frequency of Parthenium in invaded sites in University campus was 100%. [28] have studied the distribution and effect of Parthenium in Meharisub-watershed of Rajouri forest range of Jammu&Kashmir. They have reported highest frequency (92%) for Parthenium having relative frequency of 36.54% followed by Cannabissativa(25.23%) and rest of the other species having less than 12.15%. However, in the present study frequency for other species it ranged from 10 to 100%. The relative frequency value was only 14.70% for Parthenium and for other species it ranged from 1.47 to 14.70% in the present study. These values are lower than the values reported by [28]. [33] has studied the effect of P. hysterophorus on plant diversity at Shakti Nagar in Banda district of U.P.. He has reported highest frequency of 98% for Parthenium and rest of the other species showed 10 – 64% frequency, having the highest relative frequency of 29% followed by Apludomatia (19.16%) and rest of the other species having less than 6% relative frequency.[22] has studied the ecological and socioeconomic impacts of P.hysterophorusinvasion in two urban areas in Nepal. He has reported 100% frequency for P.hysterophorus, Euphorbia hirta, Imperatacylindrica and Trifoliumrepens in Partheniuminvaded site and 0 to 62% for rest of the other species at Hetaudasite, whereas the highest frequency (100%) at Bharatpur area for Partheniuminvaded site was for only P.hysterophorusand rest of the other species showed 0 to 94% frequency. [46] has studied the distribution status and the impact of Partheniumweed at Gedo zone (Southern Ethiopia). They have reported highest frequency and relative frequency 140% and 100% for Partheniumand other species these values ranged from 50 to 135% and 35.7 to 96.4%, respectively. [44] have studied the prevalence of invasive Parthenium weed in district Hafizabad, Pakistan and have mentioned frequency and relative frequency of Parthenium 51% and 2.45 %, respectively. Frequency and relative frequency of other species ranged from 5 to 79% and 0.24 to 3.80% respectively.

The density value in the present study for Parthenium was recorded 188.4m⁻² and for other species it ranged from 0.4 to 402.4 m⁻². The relative density was only 11.31% for Partheniumand for other species it was 0.02 to 24.17%. Density value for Parthenium in the present study was higher but relative density was lower than reported by [33]. Mishra has reported the highest density of 52 m⁻² for Parthenium and rest of the other species showed 0.1 to 38 m⁻², having highest relative density of 47.97% for Parthenium and rest of the other species showed 0.09 to 35.05% relative density. [56] have reported that the density value for Partheniumstudied in the five sites changes in different grasslands of Karnal, Haryana in relation to sodicity levels of the soil. The highest density of 436 m⁻² for Cynodon dactylon in site 1 and for other species it ranged from 0 to 207 m⁻². Density values for Parthenium in Nepal at Bharatpur and Hetauda sites were 48 and 298 m⁻², respectively reported by [22]. There was significant differences in the density of Parthenium. Density values for Parthenium in Bharatpur area, Nepal ranged from 19 to 69 m⁻²[22]; in Kathmandu valley 11 to 47 m⁻²[20]; 55 m⁻²in eastern Ethiopia [58]; 1.5 to 38 m⁻²in grassland of Central Nepal [59]; and 0.55 m⁻².
infallows [61]. [19] have studied the invasion of noxious alien weed P. hysterophorus in grazing lands of Lahore, Pakistan. They have reported that highest density and relative density 16.8% and 15.59% for Parthenium. Rest of the other species these values ranged from 0.02 to 7.8% and 0.018 to 7.236, respectively. [44] have mentioned that density and relative density values for Parthenium in Pakistan at Hafizabad district was 1.55 and 3.31% and for other species these values ranged from 0.10 to 2.46 and 0.12 to 4.75%, respectively. [28] have reported that the highest relative density values for Partheniumin Methi sub-watershed site was 62.75% and for other species ranged from 0.06 to 14.51%. Kumar et al. have reported the highest relative abundance was 36.54% for Parthenium and for rest of other species it ranged from 0.74 to 25.23%. [17] have studied the impact of Parthenium species diversity in GamoGofa, Ethiopia. They have showed that the IVI values for Parthenium ranged from 58.4 to 100.9. [28] have mentioned the highest IVI values for Parthenium was 129.56 and for rest of other species ranged from 007.30 to 047.72. [18] have showed that Parthenium was highly dominant species with very high IVI in the area studied by them. [26] also confirmed that importance value data (IVI) showed the superiority of Parthenium at all the locations studied. [27] said that the high IVI of the weed in general is attributed to its competitive ability, allelopathy and strong adaptive and reproductive potential. Species richness values in Nepal at Bharatpur and Hetauda sites were 9 and 9, respectively reported by [22] whereas these values ranged from 29 to 40 [46]. However, in the present study it was 1.61 only. [17] have showed that the species diversity values for Parthenium invaded area ranged from 1.15 to 1.73 and species dominance values ranged from 0.24 to 0.50. [46] have reported that the species diversity values for Parthenium ranged from 1.6 to 3.41. In the present study shoot biomass value of Parthenium was 3205.32 gm−2 and for other species 1 to 330.72 gm−2. In tropical grasslands of India the maximum and minimum values for shoot biomass ranged from 76 to 3296 and 0 to 871 gm−2 [52]. Thus except for Parthenium the total shoot biomass of other species was 786.92 gm−2 which is less than the values reported for Indian grasslands. Thus in the present study the total live shoot biomass values was 3992.24 gm−2 which is out of which Parthenium contributed 80.28%. [16] has reported that P. hysterophorus reduces pasture productivity by 90%. Dwindling effect of P. hysterophorus on grass biomass of grasslands of Queensland, Australia has also been reported by [12]. [60] have concluded that Parthenium invasion causes changes in above ground vegetation and below ground soil nutrient contents, disturbing the grassland ecosystem in Nepal. Thus Parthenium is affecting the levels of biodiversity, plant productivity, species composition and normal course of plant succession. Parthenium exhibits the ability to invade and adapt to new habitats and reduces the number of indigenous plants and biodiversity in India [40]. In the present study species richness in Parthenium invaded site was 1.45. However in Partheniumnon-invaded site species richness values have been reported from 1.64 to 2.73 from Chapra (Kumari and Jha. communicated). Thus invasion of Parthenium decreased species richness and species diversity which affects the normal course of primary plant succession fallowland.

V. Conclusion
Species composition and shoot biomass study of herbaceous vegetation developed after nine years of abandonment of cropland invaded by P. hysterophorus L. indicated that the aggressive species Parthenium has dominated the vegetation having highest IVI value. In the present study Parthenium showed higher frequency, relative frequency and IVI values compared to other studies [28],[33] but lower values for relative density and abundance compared to other studies [33]. Parthenium affected the species richness, diversity and equitability of the plant species. Thus, eradication of Parthenium is essential.

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We are highly thankful to the Head, Teaching members of the Department of Botany, J.P.University Chapra, Bihar, India, and research colleagues of our laboratory who supported directly or indirectly in the present study.

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