CHAPTER 4

RESULTS & DISCUSSION
The natural vegetation of studied forest stand comprised of tropical dry deciduous species. The data of density of various tree species are given in table: 3. It was noted that the forest comprised of 23 tree species. The trees in this forest were Acacia catechu, Anogeissus pendula, Bauhinia racemosa, Butea monosperma, Cassia fistula, Flacourtia indica, Lannea coromandelica and Tectona grandis etc.

The ground flora of the studied forest stand comprised of 67 species including legumes, forbs, annual and perennial grasses. The species of ground flora were: Achyranthus aspera, Alternanthera sessilis, Alysicarpus longifolius, Aristida adscensionis, Atylosia scarabaeoides, Boerhaavia diffusa, Brachiaria reptans, Cassia tora, Chloris virgata, Chrysopogon fulvus, Convolvulus arvensis, Convolvulus pluricaulis, Cynodon dactylon, Cyperus species, Dactyloctenium aegypticum, Dichanthium annulatum, Digitaria adscendens, Elytraria acaulis, Eragrostis ciliaris, Eragrostis diarrrhena, Eragrostis pilosa, Euphorbia hirta, Euphorbia prostrata, Evolvulus alsinoides, Gomphrena celosioides, Heteropogon contortus, Indigofera cordiflora, Leucas aspera, Leucas cephalatus, Malvestrum coromandelianum, Panicum psilopodium, Panicum miliare, Paspalum distichum, Phyllanthus niruri, Solanum xanthocarpum, Themeda quadrivalvis, Tridex procumbens, etc.

Several workers have been studied forest vegetation of Bundelkhand region (Mishra and Joshi, 1952; Bhatia, 1958; Bhatnagar, 1968; Saxena and Vyas, 1979; Trivedi et al., 1979; Athaya and Mishra, 1978-79; Tripathi.
Mishra and Joshi (1952) reported following seven forest stands in Sagar district: *Tectona grandis-Anogeissus latifolia* type; *Anogeissus latifolia-Diospyros melanoxylon* type; *Anogeissus latifolia-Diospyros melanoxylon - Terminalis tomentosa* type; *Aegle marmelos -Diospyros melanoxylon-Anogeissus latifolia* type; *Diospyros melanoxylon - Butea monosperma* type; *Anogeissus latifolia - Boswellia serrata - Diospyros melanoxylon - Butea monosperma* type; *Riverain* type.

Above seven types forest stand were regrouped by Bhatia (1958) in following four types: *Butea monosperma -Diospyros melanoxylon* type; *Anogeissus latifolia - Terminalis tomentosa - Diospyros melanoxylon* type; *Mixed Tectona grandis* type and *Riverain* type.

Patharia, Chauki, Garparaha and Bahadurpur forest of Sagar were explored by Bhatnagar (1968). They reported 238 species including trees, shrubs and herbaceous vegetation.

Saxena (1989) studied forest vegetation of Bundelkhand region. They studied Bangawa and Simrvvari forest of Jhansi range, Chandpura and Laxmanpura forest of Tikamgarh range and Nayakhera and Jharar forest of Talbahet range. In above forest communities about 59 tree and 176 herbaceous species were observed by him. Six tree species were altogether common in each of the above forest. These were: *Acacia catechu, Acacia nilotica, Anogeissus pendula, Bauhinia racemosa, Butea monosperma and Holoptelia integrifolia.*
Trivedi *et al.* (1979) recognised 14 herbaceous plant communities in forest division, Jhansi. Out of this, ten were grass communities, the two had a legume i.e. *Zornia diphylla* as co-dominant and in the rest of two communities forbs *viz.*, *Bonnaya brachiata* and *Borreria stricta*. The ground flora consisted of 10 perennial and 18 annual grasses, 12 legumes and 25 forbs species.

Athaya and Mishra (1978-79) reported 112 species of flowering plants in nine sites of tropical dry deciduous forest of Central India. Tripathi *et al.* (1983) made phytosociological studies in two forest of Jhansi and Tikamgarh districts of Bundelkhand region. They reported that in these forests *Anogeissus pendula* occurred as predominant species followed by *Butea monosperma*.

Thus Bundelkhand forest communities seems to be heterogeneous in their composition. Even the tree crops standing in the same locality were not homogeneous in their quality, density, structure and floristics. Micro-climatic differences produced due to variation in the aspect of slopes and proximity to water sources caused a very perceptible variation in the vegetation. Thus, over an area with uniform climate, micro-climatic conditions effect upon the vegetation resulting in segregation of species to form distinct stands. Main factors governing the distribution of forest types and stand variations are geological formations and the resultant soils, physiography of the tract and the biotic influences.
A close up view of *Butea monosperma* with flowering.

A close up view of flowering and fruiting of *Butea monosperma*. 
Table 3: Density per hectare of the tree species assessed during their phytosociological studies in two different forest blocks near Orchha.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the Species</th>
<th>Site A</th>
<th>Site B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acacia catechu</em></td>
<td>20</td>
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<tr>
<td>2.</td>
<td><em>Acacia leucophloea</em></td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>3.</td>
<td><em>Aegle marmelos</em></td>
<td>06</td>
<td>02</td>
</tr>
<tr>
<td>4.</td>
<td><em>Albizia lebbeck</em></td>
<td>-</td>
<td>02</td>
</tr>
<tr>
<td>5.</td>
<td><em>Anogeissus latifolia</em></td>
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<tr>
<td>6.</td>
<td><em>Anogeissus pendula</em></td>
<td>393</td>
<td>477</td>
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<tr>
<td>7.</td>
<td><em>Banheina racemosa</em></td>
<td>83</td>
<td>03</td>
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<tr>
<td>8.</td>
<td><em>Butea monosperma</em></td>
<td>159</td>
<td>156</td>
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<tr>
<td>9.</td>
<td><em>Carissa corandus</em></td>
<td>-</td>
<td>06</td>
</tr>
<tr>
<td>10.</td>
<td><em>Carissa spinarum</em></td>
<td>08</td>
<td>03</td>
</tr>
<tr>
<td>11.</td>
<td><em>Carissa fistula</em></td>
<td>58</td>
<td>04</td>
</tr>
<tr>
<td>12.</td>
<td><em>Ficus benghalensis</em></td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>13.</td>
<td><em>Flachortia romantchi (Kakai)</em></td>
<td>07</td>
<td>06</td>
</tr>
<tr>
<td>14.</td>
<td><em>Holoptelia integrifolia</em></td>
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<td>02</td>
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<td><em>Lannea coromendalica</em></td>
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<td>05</td>
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<td>16.</td>
<td><em>Madhuca longifolia</em></td>
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<td>01</td>
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<td>17.</td>
<td><em>Mitragyna parvifolia</em></td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>18.</td>
<td><em>Phoenix sylvestris (Khajur)</em></td>
<td>02</td>
<td>01</td>
</tr>
<tr>
<td>19.</td>
<td><em>Syzygium cumini</em></td>
<td>03</td>
<td>03</td>
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<tr>
<td>20.</td>
<td><em>Salmalia malabarica (Semal)</em></td>
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<tr>
<td>21.</td>
<td><em>Tectona grandis</em></td>
<td>336</td>
<td>342</td>
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<tr>
<td>22.</td>
<td><em>Terminalia arjuna</em></td>
<td>02</td>
<td>02</td>
</tr>
<tr>
<td>23.</td>
<td><em>Vitex negundo</em></td>
<td>04</td>
<td>11</td>
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**Table 4:** Importance value index and A/F ratio of the tree species assessed during their phytosociological studies.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the Species</th>
<th>IVI (S - A)</th>
<th>IVI (S - B)</th>
<th>A/F Ratio (S - A)</th>
<th>A/F Ratio (S - B)</th>
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<tr>
<td>1.</td>
<td><em>Acacia catechu</em></td>
<td>0.57</td>
<td>3.22</td>
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<td>0.183</td>
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<td>2.</td>
<td><em>Acacia leucophloea</em></td>
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<td>0.085</td>
<td>0.121</td>
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<td>3.</td>
<td><em>Aegle marmelos</em></td>
<td>5.42</td>
<td>7.64</td>
<td>0.336</td>
<td>0.599</td>
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<tr>
<td>4.</td>
<td><em>Albizia lebbek</em></td>
<td>-</td>
<td>2.53</td>
<td>-</td>
<td>0.400</td>
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<tr>
<td>5.</td>
<td><em>Anogeissus latifolia</em></td>
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<td>77.02</td>
<td>0.084</td>
<td>0.076</td>
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<td>6.</td>
<td><em>Anogeissus pendula</em></td>
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<td>0.901</td>
<td>-</td>
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<td>7.</td>
<td><em>Bauhenia racemosa</em></td>
<td>5.91</td>
<td>1.79</td>
<td>0.303</td>
<td>1.205</td>
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<tr>
<td>8.</td>
<td><em>Butia monosperma</em></td>
<td>35.82</td>
<td>27.43</td>
<td>0.039</td>
<td>0.038</td>
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<tr>
<td>9.</td>
<td><em>Carissa carandas</em></td>
<td>10.04</td>
<td>-</td>
<td>0.172</td>
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<tr>
<td>10.</td>
<td><em>Carissa spinarum</em></td>
<td>2.83</td>
<td>1.84</td>
<td>0.751</td>
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<td>11.</td>
<td><em>Carissa fistula</em></td>
<td>41.21</td>
<td>4.22</td>
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<tr>
<td>12.</td>
<td><em>Ficus benghalensis</em></td>
<td>28.93</td>
<td>30.47</td>
<td>1.205</td>
<td>1.205</td>
</tr>
<tr>
<td>13.</td>
<td><em>Flachortia romantica (Kakai)</em></td>
<td>5.27</td>
<td>6.32</td>
<td>0.168</td>
<td>0.336</td>
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<td>14.</td>
<td><em>Holoptelia integrifolia</em></td>
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<td>10.46</td>
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<td>0.599</td>
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<td>15.</td>
<td><em>Lannea coromandelica</em></td>
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<td>0.288</td>
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<td>16.</td>
<td><em>Madhuca longifolia</em></td>
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<td>3.46</td>
<td>1.198</td>
<td>1.205</td>
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<td>17.</td>
<td><em>Mitragyna parvifolia</em></td>
<td>1.38</td>
<td>6.98</td>
<td>1.205</td>
<td>1.205</td>
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<td>18.</td>
<td><em>Phoenix sylvestris (Khajur)</em></td>
<td>2.63</td>
<td>1.85</td>
<td>0.400</td>
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<td>19.</td>
<td><em>Syzygium cumini</em></td>
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<td>0.98</td>
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<td>3.614</td>
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<td>20.</td>
<td><em>Salsalum malabarica (Semal)</em></td>
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<td>0.120</td>
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<td>21.</td>
<td><em>Tectona grandis</em></td>
<td>43.85</td>
<td>34.88</td>
<td>0.105</td>
<td>2.410</td>
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<td>22.</td>
<td><em>Terminalia arjuna</em></td>
<td>6.94</td>
<td>21.51</td>
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<td>0.623</td>
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<td>23.</td>
<td><em>Vitex negundo</em></td>
<td>2.16</td>
<td>4.1</td>
<td>1.497</td>
<td>1.205</td>
</tr>
</tbody>
</table>
Table 5: Density per hectare of the Herbaceous species including grasses assessed during their Phytosociological studies in both sites.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the Species</th>
<th>Density/ Hectare</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acanthospermum hispidum</em></td>
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<tr>
<td>2.</td>
<td><em>Achyranthes aspera</em></td>
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<tr>
<td>3.</td>
<td><em>Alternanthera sessilis</em></td>
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<td>4.</td>
<td><em>Andrographis echioides</em></td>
<td>0.10</td>
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<td>5.</td>
<td><em>Blumea lacera</em></td>
<td>0.26</td>
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<tr>
<td>6.</td>
<td><em>Boerhavia diffusa</em></td>
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<tr>
<td>7.</td>
<td><em>Brachiaria kurzii</em></td>
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<td>8.</td>
<td><em>Brachiaria raptans</em></td>
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<td><em>Cassia absus</em></td>
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<td><em>Cassia pumila</em></td>
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<td><em>Cassia tora</em></td>
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<td><em>Cleome viscosa</em></td>
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<td><em>Comellina benghalensis</em></td>
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<td><em>Convolvulus arvensis</em></td>
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<td>16.</td>
<td><em>Corchorus fasciculus Lamm.</em></td>
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<td><em>Cortolasia medicaginea</em></td>
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<td>18.</td>
<td><em>Crotolaria prostrata</em></td>
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<td><em>Cynodon dactylon</em></td>
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<td><em>Cyperus corymbosus</em></td>
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<td><em>Cyperus niveus</em></td>
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<td><em>Dactyloctenium aegyptium</em></td>
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<td><em>Dactyloctenium sindicum</em></td>
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<td><em>Digitaria adsensciosis</em></td>
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<td><em>Elytraria acualis</em></td>
<td>0.34</td>
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<tr>
<td>S.No.</td>
<td>Name of the Species</td>
<td>Density/ Hectare</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------------------</td>
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<td><em>Eragrostis ciliasis</em></td>
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<td><em>Eragrostis pilosa</em></td>
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<td><em>Euphorbia prostrata</em></td>
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<td><em>Evolvulus alsinodes</em></td>
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<td><em>Hibiscus labatus</em></td>
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<td><em>Indigofera linifolia (L.)Retz</em></td>
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<td><em>Indigofera ohlonigifolia</em></td>
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<td><em>Ipomea sindica</em></td>
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<td><em>Lepidagathis incurva</em></td>
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<td><em>Linaria indica</em></td>
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<td><em>Peristrophe biocalyculata</em></td>
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<td><em>Pheosolis sub-lobatus</em></td>
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<td><em>Rungia pectinata</em></td>
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<td><em>Sesamum orientale</em></td>
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<td><em>Tephrosia strigosa</em></td>
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<td><em>Tribulus terrestris</em></td>
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<td><em>Tridex procombeus</em></td>
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<td><em>Urena lobata L.</em></td>
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<td><em>Xanthium strumarium</em></td>
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<td>66</td>
<td><em>Zornia gibbosa</em></td>
<td>0.72</td>
</tr>
</tbody>
</table>
Table 6: Importance value index and A/F ratio of the Herbaceous species including grasses assessed during their Phytosociological studies in both sites.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the Species</th>
<th>Importance value index</th>
<th>A/F - Ratio of the species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S - A</td>
<td>S - B</td>
</tr>
<tr>
<td>1.</td>
<td>Acanthospermum hispidum</td>
<td>1.6848</td>
<td>1.9193</td>
</tr>
<tr>
<td>2.</td>
<td>Achyranthus aspera</td>
<td>2.5030</td>
<td>1.6834</td>
</tr>
<tr>
<td>3.</td>
<td>Alternanthera sessilis</td>
<td>7.1174</td>
<td>5.3474</td>
</tr>
<tr>
<td>4.</td>
<td>Andrographis echioides</td>
<td>1.4056</td>
<td>1.5348</td>
</tr>
<tr>
<td>5.</td>
<td>Blumea lacera</td>
<td>2.7100</td>
<td>2.7659</td>
</tr>
<tr>
<td>6.</td>
<td>Boerhavia diffusa</td>
<td>3.0194</td>
<td>4.0848</td>
</tr>
<tr>
<td>7.</td>
<td>Brachiaria kurzii</td>
<td>4.1795</td>
<td>3.8707</td>
</tr>
<tr>
<td>8.</td>
<td>Brachyotus raptans</td>
<td>4.5944</td>
<td>4.9155</td>
</tr>
<tr>
<td>9.</td>
<td>Cassia absus</td>
<td>1.2131</td>
<td>2.4511</td>
</tr>
<tr>
<td>10.</td>
<td>Cassia pumila</td>
<td>4.7411</td>
<td>4.8552</td>
</tr>
<tr>
<td>11.</td>
<td>Cassia tora</td>
<td>35.9650</td>
<td>29.8148</td>
</tr>
<tr>
<td>12.</td>
<td>Cleome viscosa</td>
<td>2.1068</td>
<td>1.5266</td>
</tr>
<tr>
<td>13.</td>
<td>Cominella benghalensis</td>
<td>1.9736</td>
<td>2.8849</td>
</tr>
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<td>14.</td>
<td>Convolvulus arvensis</td>
<td>1.5265</td>
<td>3.0318</td>
</tr>
<tr>
<td>15.</td>
<td>Corchorus aescuans</td>
<td>6.6637</td>
<td>7.1251</td>
</tr>
<tr>
<td>16.</td>
<td>Corchorus fascisculus Lamk.</td>
<td>-</td>
<td>7.1454</td>
</tr>
<tr>
<td>18.</td>
<td>Crotonaria prostrata</td>
<td>-</td>
<td>2.5039</td>
</tr>
<tr>
<td>19.</td>
<td>Cynodon dactylon</td>
<td>3.8533</td>
<td>6.1353</td>
</tr>
<tr>
<td>20.</td>
<td>Cyperus corybosus</td>
<td>1.7180</td>
<td>2.4189</td>
</tr>
<tr>
<td>21.</td>
<td>Cyperus niveus</td>
<td>2.0754</td>
<td>2.3285</td>
</tr>
<tr>
<td>22.</td>
<td>Dactyloctenium aegyptium</td>
<td>5.3908</td>
<td>6.0385</td>
</tr>
<tr>
<td>23.</td>
<td>Dactylolctenium sindicicum</td>
<td>3.8397</td>
<td>4.0020</td>
</tr>
<tr>
<td>24.</td>
<td>Desmodium ganetocum (Linn)DC</td>
<td>2.6109</td>
<td>-</td>
</tr>
<tr>
<td>25.</td>
<td>Dicanchium annulatum</td>
<td>4.3559</td>
<td>4.8808</td>
</tr>
<tr>
<td>26.</td>
<td>Digitaria adsensionis</td>
<td>6.1099</td>
<td>6.8912</td>
</tr>
<tr>
<td>27.</td>
<td>Elytroia acualis</td>
<td>3.2021</td>
<td>4.4630</td>
</tr>
<tr>
<td>S.No.</td>
<td>Name of the Species</td>
<td>Importance value index</td>
<td>A/F - Ratio of the species</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------</td>
<td>------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S - A</td>
<td>S - B</td>
</tr>
<tr>
<td>28</td>
<td><em>Eragrostis ciliaris</em></td>
<td>17.2528</td>
<td>22.8069</td>
</tr>
<tr>
<td>29</td>
<td><em>Eragrostis pilosa</em></td>
<td>13.7819</td>
<td>15.7647</td>
</tr>
<tr>
<td>30</td>
<td><em>Euphorbia hirta</em></td>
<td>5.0297</td>
<td>4.5157</td>
</tr>
<tr>
<td>31</td>
<td><em>Euphorbia prostrata</em></td>
<td>1.9238</td>
<td>1.3991</td>
</tr>
<tr>
<td>32</td>
<td><em>Evolvulus alsinoides</em></td>
<td>3.2435</td>
<td>1.5352</td>
</tr>
<tr>
<td>33</td>
<td><em>Hibiscus labatus</em></td>
<td>1.6847</td>
<td>-</td>
</tr>
<tr>
<td>34</td>
<td><em>Indigofera linifolia</em> (L. iml.)Retz*</td>
<td>2.3764</td>
<td>1.6942</td>
</tr>
<tr>
<td>35</td>
<td><em>Indigofera oblongifolia</em></td>
<td>1.5692</td>
<td>1.6506</td>
</tr>
<tr>
<td>36</td>
<td><em>Ipomea eriocarpa</em> R. Br.</td>
<td>1.4766</td>
<td>2.3240</td>
</tr>
<tr>
<td>37</td>
<td><em>Ipomea sivica</em></td>
<td>1.2568</td>
<td>1.6211</td>
</tr>
<tr>
<td>38</td>
<td><em>Lepidagathis incurva</em></td>
<td>1.2356</td>
<td>1.3139</td>
</tr>
<tr>
<td>39</td>
<td><em>Lindenhergia indica</em></td>
<td>1.1582</td>
<td>1.3455</td>
</tr>
<tr>
<td>40</td>
<td><em>Lindernia ciliata</em></td>
<td>6.1231</td>
<td>5.1833</td>
</tr>
<tr>
<td>41</td>
<td><em>Ludwigia octovalis</em> (Jacq.) Raven.</td>
<td>3.5055</td>
<td>2.9200</td>
</tr>
<tr>
<td>42</td>
<td><em>Malvastrium coromandelium</em> (L.) Garcke</td>
<td>1.2901</td>
<td>1.6944</td>
</tr>
<tr>
<td>43</td>
<td><em>Murdenia nudiflora</em></td>
<td>5.5474</td>
<td>4.9413</td>
</tr>
<tr>
<td>44</td>
<td><em>Panicum psilopodium</em></td>
<td>8.8138</td>
<td>10.9040</td>
</tr>
<tr>
<td>45</td>
<td><em>Parthenium hysterophorus</em></td>
<td>1.0211</td>
<td>1.1619</td>
</tr>
<tr>
<td>46</td>
<td><em>Peristrophe biocolyculata</em></td>
<td>2.5475</td>
<td>2.7043</td>
</tr>
<tr>
<td>47</td>
<td><em>Phaseolus sub-lobatus</em></td>
<td>-</td>
<td>1.2130</td>
</tr>
<tr>
<td>48</td>
<td><em>Phyllanthus fraternus</em></td>
<td>4.3921</td>
<td>4.4373</td>
</tr>
<tr>
<td>49</td>
<td><em>Phyllanthus urinaria</em></td>
<td>5.1205</td>
<td>4.7155</td>
</tr>
<tr>
<td>50</td>
<td><em>Phyllanthus virgatus</em></td>
<td>3.1373</td>
<td>2.9502</td>
</tr>
<tr>
<td>51</td>
<td><em>Polygonum plebeium</em></td>
<td>-</td>
<td>1.5289</td>
</tr>
<tr>
<td>52</td>
<td><em>Rungia pectinata</em></td>
<td>22.1952</td>
<td>23.3129</td>
</tr>
<tr>
<td>53</td>
<td><em>Rungia repens</em></td>
<td>32.6489</td>
<td>21.4776</td>
</tr>
<tr>
<td>54</td>
<td><em>Sclerocarpus africanus</em></td>
<td>-</td>
<td>0.8088</td>
</tr>
<tr>
<td>55</td>
<td><em>Sesomum orientale</em></td>
<td>1.0654</td>
<td>0.6711</td>
</tr>
<tr>
<td>56</td>
<td><em>Setaria glauca</em></td>
<td>4.4377</td>
<td>5.5727</td>
</tr>
<tr>
<td>57</td>
<td><em>Sida cordata</em></td>
<td>4.9234</td>
<td>4.9057</td>
</tr>
<tr>
<td>58</td>
<td><em>Sida cordifolia</em></td>
<td>6.5794</td>
<td>5.6919</td>
</tr>
<tr>
<td>59</td>
<td><em>Sonchus arachyotus</em></td>
<td>1.6847</td>
<td>1.5546</td>
</tr>
<tr>
<td>60</td>
<td><em>Tephreria strigosia</em></td>
<td>4.3559</td>
<td>2.6674</td>
</tr>
<tr>
<td>61</td>
<td><em>Tribulus terrestris</em></td>
<td>0.9799</td>
<td>1.5150</td>
</tr>
<tr>
<td>62</td>
<td><em>Tridex procombens</em></td>
<td>3.4422</td>
<td>2.8507</td>
</tr>
<tr>
<td>63</td>
<td><em>Urena lobata L.</em></td>
<td>1.2356</td>
<td>-</td>
</tr>
<tr>
<td>64</td>
<td><em>Vernonia cinerea</em></td>
<td>2.8199</td>
<td>1.3904</td>
</tr>
<tr>
<td>65</td>
<td><em>Xanthium strumarium</em></td>
<td>1.8989</td>
<td>1.2197</td>
</tr>
<tr>
<td>66</td>
<td><em>Zornia gibbosa</em></td>
<td>4.9348</td>
<td>-</td>
</tr>
</tbody>
</table>
The phenology is an important function of forest ecosystem that relates the growth habit of a species with the physical environment. The periodic developments in plants at a place are largely determined by their changing environment. Phenology embraces all the studies of the relationships between environmental factors and periodic development phenomenon in plant. Each stage in periodic phenomenon is termed as phenophase and the sequence of different phenophases in a year called phenodynamic analysis. It is a quantitative measurement of life cycle or specific phenophase. The main phenophases in plants are *viz.*, seed germination, bud bursting, leaf development, flowering time, fruit and seed dispersal, senescence and litter fall (Leith, 1970).

The phenological studies are useful in determining the character of forest floor composed of different species and in the preparation of the suitable sampling plans for the litter layer of forests (Bhatnagar, 1968). In the present study phenological calendar of tree species ranged between July 1998 to June 1999.

I. **Leafing**

The average period of commencement and completion of leafing for the various species are given in table: 4 and figure: 4. On the basis of monthly field observation it was found that all tree species beared new foliage during summer period. However, commencement and completion of foliage varied according to particular species. In *Anogeissus pendula, Butea monosperma* and *Bauhinia racemosa* leafing started in the beginning of
April and completed till the end of June. *Acacia catechu, Cassia fistula, Lankea coromandelica* and *Tectona grandis* started leafing in the beginning of May and by the end of June completed where as in the case of *Flacourtia indica* new foliage arised in the beginning of March and leafing completed by the end of May.

From above studies it was cleared that all tree species of the forest stand under study put on new foliage during summer season. Thus summer leafing was a prominant phenomenon in this forest stand.

In dry deciduous forest, similar leafing pattern of *Anogeissus pendula* was observed by Tripathi (1987). Studies carried out in the mixed dry deciduous forest at Sagar by Joseph (1977) revealed that nearly 92 per cent of tree species beared new foliage during summer season. The study of leafing in mixed dry deciduous forest of Sagar (Bhatnagar 1968), in tropical rain forest of southern Nigeria (Njoku, 1963), in semi-deciduous forest of north western Costa Rica (Daubenmire, 1972), and at New forest of Dehradun (Krishnaswamy and Mathuda, 1954) also showed that summer leafing was a prominant phenomenon in these forests.

Arjunan *et al.* (1995) found that emergence of new leaves delayed 15-30 days due to more humidity and low temperature. The replacement strategy during summer months appears to minimize stress by leaf fall at such period and maximize photosynthetic activity during wet warm season of th year through flushing (Njoku, 1963; Shukla and Ramakrishnan 1982).
Table 7: Leafing behaviour of tree species within the forest stand.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Species</th>
<th>Month of Beginning</th>
<th>Month of Completion</th>
<th>Duration of leafing in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acacia catechu</td>
<td>May</td>
<td>June</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Anogeissus pendula</td>
<td>April</td>
<td>June</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Bauhinia racemosa</td>
<td>April</td>
<td>June</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>Butea monosperma</td>
<td>April</td>
<td>June</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>Cassia fistula</td>
<td>May</td>
<td>June</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>Flacourtia indica</td>
<td>March</td>
<td>May</td>
<td>3</td>
</tr>
<tr>
<td>7.</td>
<td>Lannea coromandelica</td>
<td>May</td>
<td>June</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Tectona grandis</td>
<td>May</td>
<td>June</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 3: Period of leafing of tree species within the forest stand.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Species</th>
<th>Period of leafing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acacia catechu</td>
<td>I-------------I</td>
</tr>
<tr>
<td>2.</td>
<td>Anogeissus pendula</td>
<td>I-------------I</td>
</tr>
<tr>
<td>3.</td>
<td>Bauhinia racemosa</td>
<td>I-------------I</td>
</tr>
<tr>
<td>4.</td>
<td>Butea monosperma</td>
<td>I-------------I</td>
</tr>
<tr>
<td>5.</td>
<td>Cassia fistula</td>
<td>I-------------I</td>
</tr>
<tr>
<td>6.</td>
<td>Flacourtia indica</td>
<td>I-------------I</td>
</tr>
<tr>
<td>7.</td>
<td>Lannea coromandelica</td>
<td>I-------------I</td>
</tr>
<tr>
<td>8.</td>
<td>Tectona grandis</td>
<td>I-------------I</td>
</tr>
</tbody>
</table>
II. Leaf fall:

The leaf fall observation is presented in the table: 8 and figure: 4. In the present study leaf fall was found to be seasonal and different tree species shed their leaves at different intervals during the season. On the basis of leaf fall tendency two major leaf fall periods were recognised viz., winter leaf fall and summer leaf fall.

IIA. Winter leaf fall:

Winter leaf fall period covered months from October to March. Species in which leaf fall occurred during this period were Acacia catechu, Anogeissus pendula, Bauhinia racemosa, Cassia fistula, Flacourtia indica, Lannea coromandelica and Tectona grandis. According to the tree species initiation and completion of defoliation and leaf fall duration varied (Table: 5 and figure: 5).

IIB. Summer leaf fall:

Summer leaf fall period covered months from February to April. In the present study only Butea monosperma shedded their leaves during this period.

From above observation it was concluded that except Butea monosperma all other tree species of this forest stand shedded their leaves during winter period.

The observation on leaf fall have also been made by many workers in different forest stands of the world. It have been well explored that in a forest leaf fall is generally determined by geology, environment factors such as moisture status of soil, temperature and relative humidity.

In dry deciduous forests of Sagar, seasonal leaf fall was observed
earlier by Bhatnagar (1968). They observed that winter and early summer leaf fall was a prominent phenological feature of forests of Sagar. Joseph (1977) have also made observation on leaf fall. They observed two phases of leaf fall i.e. winter leaf fall and summer leaf fall. They also found that about 87 per cent tree species of this forest stand shedded their leaves during winter leaf fall phase. In dry deciduous forest, similar observation on *Anogeissus pendula* was made by Tripathi (1987). This supports observation obtained in the present study.

In warm temperate forests, the leaf is nearly a continuous phenomenon round the year. Some times it was maximum from January to March (Hatch, 1955) while in other cases it found more in warm winter months i.e. in October to November (Miller and Hurst, 1957). Graciela Sanchez and Javier Sanchez (1995) have noted that in tropical rain forest, Los Tuxtlas, leaf fall occurred continuously through the year and peaked during the dry season. In tropical moist deciduous forest leaf fall was observed throughout the year with maximum fall during January and February (Singh *et al.*, 1993). Sharma and Pande (1989) also studied that in Dehradun forest, the leaf fall occurred throughout the year. Arjunan *et al.*, (1995) suggested that leaf fall is delayed due to rain and high temperature and advanced due to drought and low temperature.

III. **Flowering:**

The field observations about the average period of beginning and completion of flowering for the various tree species are presented in table: 9 and figure: 5. A perusal of this revealed two major periods of flowering i.e. Rain flowering and Summer flowering.
Table 8: Leaf fall behaviour of tree species with in the forest stand.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Species</th>
<th>Month of Beginning</th>
<th>Month of Completion</th>
<th>Duration of leaf fall in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acacia catechu</td>
<td>November</td>
<td>March</td>
<td>5</td>
</tr>
<tr>
<td>2.</td>
<td>Anogeissus pendula</td>
<td>December</td>
<td>March</td>
<td>4</td>
</tr>
<tr>
<td>3.</td>
<td>Bauhinia racemosa</td>
<td>November</td>
<td>March</td>
<td>5</td>
</tr>
<tr>
<td>4.</td>
<td>Butea monosperma</td>
<td>February</td>
<td>April</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>Cassia fistula</td>
<td>December</td>
<td>March</td>
<td>4</td>
</tr>
<tr>
<td>6.</td>
<td>Flacourtia indica</td>
<td>November</td>
<td>March</td>
<td>5</td>
</tr>
<tr>
<td>7.</td>
<td>Lannea coromandelica</td>
<td>October</td>
<td>December</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>Tectona grandis</td>
<td>December</td>
<td>March</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 4: Period of leaf fall of tree species with in the forest stand.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Species</th>
<th>Period of leaf fall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O--------N--------D--J--F--M--A--M--J--A--S--</td>
</tr>
<tr>
<td>1.</td>
<td>Acacia catechu</td>
<td>I-------------------</td>
</tr>
<tr>
<td>2.</td>
<td>Anogeissus pendula</td>
<td>I-------------------</td>
</tr>
<tr>
<td>3.</td>
<td>Bauhinia racemosa</td>
<td>I-------------------</td>
</tr>
<tr>
<td>4.</td>
<td>Butea monosperma</td>
<td>I-------------------</td>
</tr>
<tr>
<td>5.</td>
<td>Cassia fistula</td>
<td>I-------------------</td>
</tr>
<tr>
<td>6.</td>
<td>Flacourtia indica</td>
<td>I-------------------</td>
</tr>
<tr>
<td>7.</td>
<td>Lannea coromandelica</td>
<td>I-------------------</td>
</tr>
<tr>
<td>8.</td>
<td>Tectona grandis</td>
<td>I-------------------</td>
</tr>
</tbody>
</table>
Table 9: Flowering behaviour of tree species within forest stand.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Species</th>
<th>Month of Beginning</th>
<th>Month of Completion</th>
<th>Duration of flowering in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acacia catechu</td>
<td>May</td>
<td>July</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Anogeissus pendula</td>
<td>August</td>
<td>September</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Bauhinia racemosa</td>
<td>April</td>
<td>May</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Butea monosperma</td>
<td>March</td>
<td>April</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Cassia fistula</td>
<td>May</td>
<td>July</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>Flacourtia indica</td>
<td>March</td>
<td>April</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Lannea coromandelica</td>
<td>February</td>
<td>March</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Tectona grandis</td>
<td>July</td>
<td>September</td>
<td>3</td>
</tr>
</tbody>
</table>

Figure 5: Period of flowering of tree species within the forest stand.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Species</th>
<th>Period of flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acacia catechu</td>
<td>[-------------------]</td>
</tr>
<tr>
<td>2</td>
<td>Anogeissus pendula</td>
<td>[-------------------]</td>
</tr>
<tr>
<td>3</td>
<td>Bauhinia racemosa</td>
<td>[-------------------]</td>
</tr>
<tr>
<td>4</td>
<td>Butea monosperma</td>
<td>[-------------------]</td>
</tr>
<tr>
<td>5</td>
<td>Cassia fistula</td>
<td>[-------------------]</td>
</tr>
<tr>
<td>6</td>
<td>Flacourtia indica</td>
<td>[-------------------]</td>
</tr>
<tr>
<td>7</td>
<td>Lannea coromandelica</td>
<td>[-------------------]</td>
</tr>
<tr>
<td>8</td>
<td>Tectona grandis</td>
<td>[-------------------]</td>
</tr>
</tbody>
</table>
III.A. Rain flowering:

The period covered the months from July to September. Species which showed flowering during this period were *Anogeissus pendula* and *Tectona grandis*. In *Anogeissus pendula* the flowering initiated in the month of August and completed till the end of September while in *Tectona grandis* the flowering initiated in the month of July and continued till the end of September.

III.B. Summer flowering:

The period covered the months from February to June. Many species started their flowering during early summer but a few species showed flowering during late summer. According to the tree species initiation and completion of flowering varied (table: 9 and figure: 5). These observations revealed that majority of tree species of this stand showed flowering during summer season.

Daubenmire (1972) was observed maximum flowering in dry months in the semi deciduous forests of Costa Rica. Joseph (1977) also observed that nearly 73 percent of tree species of dry deciduous forest of Sagar showed flowering during summer season. Ward and Henry (1961) reported that, *Chestnut oak*, *Scrub chestnut oak* and *Burr oak* showed no seasonal variation in time interval of flowering but in *Whilt oak* there were three distinct periods of flower emergence. Tripathi (1987) also studied similar flowering behaviour of *Anogeissus pendula* in dry deciduous forest.

IV. Fruit fall:

The field observations about the average period of beginning and completion of fruit fall for the various tree species are presented in table:10
Table 10: Fruit fall behaviour of tree species within forest stand.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Species</th>
<th>Month of Beginning</th>
<th>Month of Completion</th>
<th>Duration of fruit fall in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acacia catechu</td>
<td>November</td>
<td>March</td>
<td>5</td>
</tr>
<tr>
<td>2.</td>
<td>Anogeissus pendula</td>
<td>January</td>
<td>February</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Bauhinia racemosa</td>
<td>December</td>
<td>March</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>Butea monosperma</td>
<td>June</td>
<td>June</td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Cassia fistula</td>
<td>January</td>
<td>March</td>
<td>3</td>
</tr>
<tr>
<td>6.</td>
<td>Flacourtia indica</td>
<td>June</td>
<td>June</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>I.annae coromandelica</td>
<td>May</td>
<td>June</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Tectona grandis</td>
<td>January</td>
<td>April</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 6: Period of fruit fall of tree species within the forest stand.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Species</th>
<th>Period of fruit fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acacia catechu</td>
<td>I-------------------I</td>
</tr>
<tr>
<td>2.</td>
<td>Anogeissus pendula</td>
<td>I--------I</td>
</tr>
<tr>
<td>3.</td>
<td>Bauhinia racemosa</td>
<td>I-------------------I</td>
</tr>
<tr>
<td>4.</td>
<td>Butea monosperma</td>
<td>I-------I</td>
</tr>
<tr>
<td>5.</td>
<td>Cassia fistula</td>
<td>I--------I</td>
</tr>
<tr>
<td>6.</td>
<td>Flacourtia indica</td>
<td>I-------I</td>
</tr>
<tr>
<td>7.</td>
<td>I.annae coromandelica</td>
<td>I--------I</td>
</tr>
<tr>
<td>8.</td>
<td>Tectona grandis</td>
<td>I-------------------I</td>
</tr>
</tbody>
</table>
and figure: 6 A perusal of these revealed that except *Butea monosperma* *Lannea coromandelica* and *Flacourtia indica* all other tree species exhibited the fruit fall during the months of November to April. *Anogeissus pendula*, *Cassia fistula* and *Tectona grandis* initiated fruit fall in the beginning of January and completed by the end of February, March and April, respectively. *Butea monosperma* and *Flacourtia indica* showed such activity during June. In *Acacia catechu* fruit fall started in the November and completed till the end of March. In the case of *Lannea coromandelica* fruit fall occurred during May and June.

From these observations it is cleared that winter fruit fall was a prominent phenomenon in this forest stand. Tripathi (1987) have observed similar fruit fall pattern of *Anogeissus pendula* in dry deciduous forest. Joseph (1977) have concluded that nearly 52 percent of tree species of dry deciduous forest had their fruit fall during summer season while about 10 percent of tree species had it during rainy season.
Part - III

Nutrients Return Through Leaf Litter fall

I. Percentage of nutrients (Mean Annual) leaf litter:

Table: 11 and figure: 7 shows mean annual percentage of nutrients in leaf litter of investigated tree species. It was found that in leaf litter, nutrient was in the order of Ca>N>K>P. It was observed that concentration of nitrogen ranged from 0.73 to 1.41 per cent. Leaf litter of Acacia catechu and Butea monosperma contained higher percentage of nitrogen (1.41 and 1.35 per cent nitrogen, respectively). Besides both above species, Anogeissus pendula, Bauhinia racemosa and Cassia fistula also showed more than one per cent nitrogen. Flacourtia indica, Lannea coromandelica and Tectona grandis, whose nitrogen content ranged between 0.73 to 0.91 per cent, were poorest in this respect.

Table 11: Mean annual concentration (per cent dry mass) of nutrients in leaf litter of tree species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Nutrient Concentration (Per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Acacia catechu</td>
<td>1.41</td>
</tr>
<tr>
<td>Anogeissus pendula</td>
<td>1.05</td>
</tr>
<tr>
<td>Bauhinia racemosa</td>
<td>1.21</td>
</tr>
<tr>
<td>Butea monosperma</td>
<td>1.35</td>
</tr>
<tr>
<td>Cassia fistula</td>
<td>1.01</td>
</tr>
<tr>
<td>Flacourtia indica</td>
<td>0.91</td>
</tr>
<tr>
<td>Lannea coromandelica</td>
<td>0.73</td>
</tr>
<tr>
<td>Tectona grandis</td>
<td>0.89</td>
</tr>
</tbody>
</table>
Fig. 7: Mean annual concentration (per cent dry mass) of nutrients in leaf litter of tree species.

(AC=Acacia catechu, AP=Anogeissus pendula, BM=Butea monosperma, BR=Bauhinia racemosa, CF=Cassia fistula, FL=Flacourtia indica, LC=Lannea coromandelica, TG=Tectona grandis)
Table 12: Nutrient concentration in leaf litter at different localities of India

<table>
<thead>
<tr>
<th>Species</th>
<th>Localities</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Authority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anogeissus latifolia</td>
<td>Sagar, M.P.</td>
<td>0.84</td>
<td>0.07</td>
<td>0.29</td>
<td>2.23</td>
<td>Upadhyaya (1955)</td>
</tr>
<tr>
<td></td>
<td>Varanasi, U.P.</td>
<td>1.25</td>
<td>0.44</td>
<td>0.44</td>
<td>3.81</td>
<td>Singh (1969)</td>
</tr>
<tr>
<td></td>
<td>Morni hills, Haryana</td>
<td>1.89</td>
<td>0.091</td>
<td>0.37</td>
<td>1.49</td>
<td>Gupta and Rout (1992)</td>
</tr>
<tr>
<td></td>
<td>Coimbatore, Tamil Nadu</td>
<td>2.7</td>
<td>0.07</td>
<td>0.70</td>
<td>-</td>
<td>Singh et al. (1993)</td>
</tr>
<tr>
<td>Anogeissus pendula</td>
<td>Tikamgarh, M.P.</td>
<td>1.11</td>
<td>0.086</td>
<td>0.48</td>
<td>3.9</td>
<td>Present study</td>
</tr>
<tr>
<td>Butea monosperma</td>
<td>Varanasi, U.P.</td>
<td>2.26</td>
<td>0.25</td>
<td>0.75</td>
<td>1.85</td>
<td>Singh (1969)</td>
</tr>
<tr>
<td></td>
<td>Sagar, M.P.</td>
<td>1.50</td>
<td>0.05</td>
<td>0.41</td>
<td>2.40</td>
<td>Upadhyaya (1955)</td>
</tr>
<tr>
<td></td>
<td>Tikamgarh, M.P.</td>
<td>1.28</td>
<td>0.053</td>
<td>0.36</td>
<td>3.3</td>
<td>Present study</td>
</tr>
<tr>
<td>Lannea coromandelica</td>
<td>Morni hills, Haryana</td>
<td>2.18</td>
<td>0.090</td>
<td>0.27</td>
<td>0.65</td>
<td>Gupta and Rout (1992)</td>
</tr>
<tr>
<td></td>
<td>Tikamgarh, M.P.</td>
<td>0.77</td>
<td>0.056</td>
<td>0.47</td>
<td>2.7</td>
<td>Present study</td>
</tr>
<tr>
<td>Tectona grandis</td>
<td>Sagar, M.P.</td>
<td>0.77</td>
<td>0.040</td>
<td>0.39</td>
<td>2.28</td>
<td>Upadhyaya (1955)</td>
</tr>
<tr>
<td></td>
<td>Varanasi, M.P.</td>
<td>0.78</td>
<td>0.18</td>
<td>0.24</td>
<td>2.54</td>
<td>Singh (1969)</td>
</tr>
<tr>
<td></td>
<td>Dehradun, U.P.</td>
<td>0.98</td>
<td>0.21</td>
<td>0.37</td>
<td>2.46</td>
<td>Seth et al. (1963)</td>
</tr>
<tr>
<td></td>
<td>Erode district, Tamil Nadu</td>
<td>1.90</td>
<td>0.02</td>
<td>1.31</td>
<td>2.24</td>
<td>Shanmughavel and francis (1998)</td>
</tr>
<tr>
<td></td>
<td>Tikamgarh, M.P.</td>
<td>0.82</td>
<td>0.060</td>
<td>0.34</td>
<td>2.2</td>
<td>Present study</td>
</tr>
</tbody>
</table>
The percentage of phosphorus content of leaf litter of these species was in general very low. The amount of phosphorus in different tree species ranged between 0.039 to 0.089 per cent. Highest amount was present in *Anogeissus pendula* (0.089 per cent). Other species were comparatively poorer in phosphorus content, the lowest amount was found in *Cassia fistula* (0.039 per cent).

Leaf litter of studied species contained less than one per cent potassium. The amount of potassium in different species ranged between 0.27 to 0.91 per cent and seemed to be more variable. Highest amount was observed in *Bauhinia racemosa* (0.91 per cent). Besides *Bauhinia racemosa*, only *Flacourtia indica* showed more than 0.50 per cent potassium. However, the lowest concentration of potassium (0.27 per cent) was observed in *Acacia catechu* followed by *Tectona grandis* (0.34 per cent). The status of calcium content of leaf litter was in general very high and showed large variation amongst different species. The concentration of calcium in different species ranged between 2.0 to 4.1 per cent. Higher percentage was found to be in *Cassia fistula* (4.1 per cent) and *Bauhinia racemosa* (4.0 per cent). Three other species namely, *Acacia catechu*, *Anogeissus pendula* and *Butea monosperma* also exhibited high calcium content (3.3-3.9 per cent), other species were comparatively poorer in calcium and the lowest amount was found in *Tectona grandis* (2.0 per cent).

The element concentration in leaf litter of teak was in the order of Ca>N>K>P. (Shanmughavel and Francis 1998). In leaf litter of teak similar trend of nutrient concentration was observed by Seth. *et al.*, (1963). The same is the situation in the present study. Sharma and Pande (1989) observed that percentage of Ca and N was higher than K, Mg and P, in all the litter fraction. In general, litter nutrient concentration were greater in the deciduous species sal and teak than in the evergreen pines and eucalyptus.
Singh et al. (1993) studied nutrient cycling in moist deciduous forest, Coimbatore. They observed that the percentage of nitrogen ranged from 1.4 to 2.7 per cent whereas the concentration of phosphorus and potassium do not show much variation among the species.

Data presented above indicate that leaf litter of different species reveal large variations with respect to amount of various chemical constituents. It is evident from Table 18 that even leaf litter of same species is not exhibite similar concentration of nutrient in different, climatic condition, latitude and altitude. Thus variation in the concentration of leaf litter nutrients is not a species attribute but depends upon the combind effect of soil nutrients status, growth of the stand and tree growth formations (Sharma and Pande 1989).

II. Nutrient return though leaf fall:

The annual leaf fall of 3994.93 kg/ha/yr in present forest brought back to substratum with low quantities of nitrogen (38.528 kg/ha), phosphorus (2.971 kg/ha), potassium (15.959 kg/ha) and calcium (128.582 kg/ha). Specieswise nitrogen Table 13: Annual return of nutrients through leaf fall by different tree species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Nutrient return (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>Acacia catechu</td>
<td>1.305</td>
</tr>
<tr>
<td>Anogeissus pendula</td>
<td>16.111</td>
</tr>
<tr>
<td>Bauhinia racemosa</td>
<td>0.733</td>
</tr>
<tr>
<td>Butea monosperma</td>
<td>6.830</td>
</tr>
<tr>
<td>Cassia fistula</td>
<td>0.967</td>
</tr>
<tr>
<td>Flacourtia indica</td>
<td>0.635</td>
</tr>
<tr>
<td>Lannea coromandelica</td>
<td>3.047</td>
</tr>
<tr>
<td>Tectona grandis</td>
<td>8.900</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38.528</strong></td>
</tr>
</tbody>
</table>
Fig. 8: Annual return of nutrients (kg/ha/yr) through leaf litter of different tree species.

(AC=Acacia catechu, AP=Anogeissus pendula, BM=Butea monosperma, BR=Bauhinia racemosa,
CF=Cassia fistula, FL=Flacourtia indica, LC=Lannea coromandelica, TG=Tectona grandis)
returned followed the order *Anogeissus pendula, Tectona grandis, Butea monosperma, Lannea coromandelica, Acacia catechu, Cassia fistula, Bauhinia racemosa* and *Flacourtia indica* their contribution in kg/ha was being 15.11, 8.90, 6.83, 3.04, 1.305, 0.967, 0.733 and 0.635 respectively (table 13; figure 8).

Monthwise nitrogen return through leaf fall is showed in table: 14 and figure: 9. The total nitrogen return recorded in winter was 25.78 kg/ha, in summer 8.101 kg/ha and in rainy season 4.646 kg/ha constituting nearly 66.91, 21.03 and 12.06 per cent respectively. Maximum amount of nitrogen returned in between November to March. (Table :8).

Table 14 : Monthwise return of nutrient through leaf fall.

<table>
<thead>
<tr>
<th>Months</th>
<th>Nutrient return (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
</tr>
<tr>
<td>July</td>
<td>1.307</td>
</tr>
<tr>
<td>August</td>
<td>0.951</td>
</tr>
<tr>
<td>September</td>
<td>0.788</td>
</tr>
<tr>
<td>October</td>
<td>1.600</td>
</tr>
<tr>
<td>November</td>
<td>3.988</td>
</tr>
<tr>
<td>December</td>
<td>6.225</td>
</tr>
<tr>
<td>January</td>
<td>8.093</td>
</tr>
<tr>
<td>February</td>
<td>7.475</td>
</tr>
<tr>
<td>March</td>
<td>5.211</td>
</tr>
<tr>
<td>April</td>
<td>2.890</td>
</tr>
<tr>
<td>May</td>
<td>-</td>
</tr>
<tr>
<td>June</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>38.528</td>
</tr>
</tbody>
</table>

69
Fig. 9: Monthwise return of nutrients through leaf litter by different tree species.
Annual return of phosphorus through leaf litter was considerably low than that of other nutrient. Alike nitrogen return, phosphorus return was also found to be maximum during winter months followed by rainy and summer. Specieswises return of phosphorus showed that more than 50 per cent phosphorus was returned by leaf litter of *Anogeissus pendula* where as rest was by the other tree species of the forest stand.

Besides *Anogeissus pendula*, *Tectona grandis*, *Butea monosperma*, *Bauhinia racemosa* and *Lannea coromandelica* were the tree species having more than 0.100 kg/ha return of phosphorus.

Annual return of potassium through leaf fall also followed a definite trend i. e. maximum amount of potassium returned during winter months followed by summer and rainy. *Anogeissus pendula* returned higher amount of potassium (8.050 kg/ha) constituting 50.44 per cent while *Tectona grandis* and *Butea monosperma* were returned 3.882 kg/ha and 1.929 kg/ha of potassium, respectively.

The total annual return of calcium through leaf fall followed the order *Anogeissus pendula*, *Tectona grandis*, *Butea monosperma*, *Lannea coromandelica*, *Cassia fistula*, *Acacia catechu*, *Bauhinia racemosa* and *Flacourtia indica*, their contribution in kg/ha was being 69.819, 21.475, 16.799, 7.533, 4.822, 4.002, 2.532 and 1.600 respectively. Out of all species, *Anogeissus pendula* alone returned 52.30 per cent calcium through leaf fall. *Tectona grandis* and *Butea monosperma* also returned high amount of calcium through leaf fall, 16.70 per cent and 13.01 per cent respectively, than that of other tree species.

Thus *Anogeissus pendula*, *Tectona grandis* and *Butea monosperma* were returned 108.090 (84.06 per cent) calcium through leaf fall while rest was contributed by remaining tree species.
It can, therefore, be concluded that in this forest more than 80 per cent nutrient (N.P.K and Ca) returned through leaf fall of *Anogeissus pendula, Tectona grandis* and *Butea monosperma*. Out of total nutrient returned, more than 65 per cent (except in the case of nitrogen, 63.63 per cent) nutrient returned during winter months. Alike nutrient concentration, the order of nutrient return through leaf fall of all the tree species was Ca>N>K>P.

Various workers have been observed annual return of nutrient in different forest stands and plantations (Seth *et al.*, 1963; Singh, 1968; Vyas *et al.*, 1976; George, 1986; Vogt *et al.*, 1986; George and Varghese, 1990; Gupta and Rout, 1992; Singh *et al.*, 1993; Shanmughavel and Francis, 1998; Totey *et al.*, 1998; Pandey *et al.*, 2001).

Singh (1968) studied nutrient return in mixed tropical deciduous forest of Varanasi. They found that 18-54, 1-28, 6-31 kg/ha N, P, K, respectively were return through litter fall. The values of nutrient return through leaf fall for studied forest falls within range reported by Singh (1968). Seth *et al.* (1963) studied return of nutrients in plantation at New forest Dahrudun, They reported that nutrients return through leaf fall of *Tectona grandis* was 52.22, 11.19, 19.72 and 131.09 kg/ha for N, P, K and Ca, repectively.

Vogt *et al.* (1986) reported return of nitrogen from litter fall and fine root turnover in evergreen forest and deciduous forest was 90 and 70 kg/ha, repectively. while George (1986) observed return of N, P, K and Ca was 29.8, 1.63, 15.0 and 40.2 kg/ha/yr from litter of *Eucalyptus* hybrid. Sugar (1989) studied nutrient return through litter of different tree species and found that the nutrients through litter was in range of 19.53-34.74 kg/ha for N, 1.15-3.14 kg/ha for total P, 9.24-25.39 kg/ha for total K and 26.39-35.94 kg/ha for Ca among tree species.
On an annual basis 238 kg/ha of N, 9 kg/ha of P and 89 kg/ha of K were returned through litter fall (Singh et al., 1993). Gupta and Rout (1992) reported that in a mixed dry deciduous forest nutrient return through litter fall was 165 N, 146 Ca, 49 Mg and 11 P.

Thus values of nutrient return through litter fall in different forest stands and plantations varied quite considerably. These variations may be attributed to, firstly, the density and quality of stand, soil nutrients status, and secondly, to latitude and altitude of locality.

III. Structural carbohydrates:

Structural carbohydrates viz., neutral detergent fibre (NDF), acid detergent fibre (ADF), hemi-cellulose, cellulose and lignin were also estimated in the leaf litter of tree species. The data on structural carbohydrates are presented in table: 17. It was observed that NDF content of leaf litter was quite high. Leaf litter of *Lannea coromandelica* and *Butea monosperma* contained higher percentage of NDF (61.34 and 60.11 per cent, respectively). Besides leaf litter of both these tree species, *Acacia catechu, Bauhinia racemosa* and *Tectona grandis* also showed more than 50 per cent NDF where as *Anogeissus pendula, Cassia fistula* and *Flacourtia indica* whose NDF content ranged between 53.47 to 49.11 per cent, were comparatively poorest in this respect.

The status of ADF content of leaf litter ranged between 29.29 to 49.50 per cent. Highest amount of ADF content was found to be in leaf litter of *Butea monosperma* (49.50 per cent). Leaf litter of *Acacia catechu, Bauhinia racemosa, Lannea coromandelica* and *Tectona grandis* contained more than 40 per cent ADF content where as less than 40 per cent was observed in *Anogeissus pendula, Cassia fistula, and Flacourtia indica.*
Cellulose content in leaf litter of different tree species ranged between 16.88 to 26.29 per cent. Maximum and minimum amount of cellulose was observed in Bauhinia racemosa and Lannea coromandelica, respectively. In Acacia catechu, Anogeissus pendula, Flacourtia indica, Cassia fistula cellulose content showed a little variation (16.05 to 19.94 per cent). Butea monosperma also contained more than 20 per cent cellulose besides Bauhinia racemosa.

Table 15: Structural carbohydrates of tree species (Per cent on dry matter basis).

<table>
<thead>
<tr>
<th>Species</th>
<th>Structural carbohydrates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NDF (%)</td>
</tr>
<tr>
<td>Acacia catechu</td>
<td>52.44</td>
</tr>
<tr>
<td>Anogeissus pendula</td>
<td>43.47</td>
</tr>
<tr>
<td>Bauhinia racemosa</td>
<td>56.84</td>
</tr>
<tr>
<td>Butea monosperma</td>
<td>60.11</td>
</tr>
<tr>
<td>Cassia fistula</td>
<td>49.11</td>
</tr>
<tr>
<td>Flacourtia indica</td>
<td>46.20</td>
</tr>
<tr>
<td>Lannea coromandelica</td>
<td>61.24</td>
</tr>
<tr>
<td>Tectona grandis</td>
<td>54.65</td>
</tr>
</tbody>
</table>

The percentage of hemi-cellulose in the leaf litter of different tree species ranged between 9.28 to 24.35 per cent. Minimum and maximum percentage of hemi-cellulose was found to be in Anogeissus pendula and Lannea coromandelica where as remaining tree species exhibited less than 16 per cent hemi-cellulose.

Lignin content of each tree species varied widely with maximum 28.36 per cent in Lannea coromandelica where as minimum of 14.60 per cent in Flacourtia indica. Besides Lannea coromandelica, Butea monosperma also contained higher percentage of Lignin (27.15 per cent). Bauhinia racemosa, Tectona grandis and
*Acacia catechu* also contained more than 20 per cent lignin content where as *Cassia fistula* contained low (15.60 per cent) lignin content besides *Flacourtia indica*.

Leaves of twenty multipurpose tree were chemically analysed by Ramana *et al.*, (1999) with a view to using as animal feed. They observed that leaves of *Butea monosperma* contained 50.61 per cent NDF, 35.60 per cent ADF, 15.12 per cent Cellulose, 15.02 per cent hemi-cellulose and 13.07 per cent lignin where as comparatively very low NDF (29.13 per cent), ADF (19.29 per cent), Cellulose (6.54 per cent), hemi-cellulose (9.84 per cent) and lignin (6.30 per cent) was found to be in *Anogeissus pendula* leaves fodder.

The extensive information on chemical composition of 75 tree leaf fodders was published by Sen *et al.*, (1978). They reported that leaf fodder of *Acacia catechu* contained 50.60, 35.30, 22.80, 15.30, and 11.30 per cent NDF, ADF, cellulose, content of NDF (71.40 per cent), ADF (45.60 per cent), cellulose (30.30 per cent), hemi-cellulose (25.80 per cent), and lignin (11.90 per cent) where as low NDF (33.20 per cent), ADF (23.70 per cent), cellulose (13.00 per cent), hemi-cellulose (9.50 per cent), lignin (10.30 per cent) was found in *Cassia fistula* leaf fodder.

Sharma *et al.*, (1990) Studied chemical composition, intake and apparent digestibility of *Dichrostachys cinerea* (brij-Babul) foliage in goats. They found that the feed was rich in CP (13.13 per cent), NDF (74.29 per cent), lignin (10.89 per cent), ADF(63.45 per cent) hemi-cellulose (10.84 per cent) and Cellulose (50.47 per cent).

Upadhyay and Ramchandra (1990) studied chemical composition and nutrient availability of some browse species of Bundelkhand region for goat and
sheep production. They reported that leaves fodder of *Acacia catechu* showed 29.49 per cent NDF, 25.70 per cent ADF and 12.32 per cent lignin whereas slightly higher percentage of NDF (32.43 per cent), ADF (26.87 per cent) and lower percentage of lignin (8.90 per cent) was found to be in *Flacourtia indica*.

Data presented above indicate that leaves of different and same tree species exhibit a wide variation with respect to various structural carbohydrates. These variations may be attributed to, firstly, climatic condition, age of particular tree, and secondly, to season in which leaves collected.
I. Structure of Substratum:

Litter on the forest substratum has been of interest to numerous investigators. The stratification of the forest floor into morphological distinct layers has been earlier suggested by a number of workers and several nomenclatural systems have emerged. Three major layers of forest floor has been recognised: an upper most layer of undecomposed litter; a middle one fragment and a bottom one of amorphous and finely divided organic matter i.e. humus layer. (Hesselman, 1925; Lutz and Chandler, 1947; Drift, 1951).

In the present study forest substratum comprised only two strata: litter layer (L-layer) and fragment (F-layer). In tropical deciduous forests due to the fast decomposition and mineralization and seasonal leaf fall, humus layer was not observed (Mohr and Van Baren, 1959). Similar observation in the substratum of tropical dry deciduous forest have also made by Joseph (1977). Forest floor with three strata was also found by a number of workers in tropical rain forest, is due to the fact that although decomposition is fast but leaf fall continuous throughout the year (Jenny et al., 1949; Nye, 1961).

The forest floor is influenced by the vegetation and climate of the area and accumulate more in cool forest as compared to those of warm regions (Weetman and Webber, 1972). In temperate forests the leaf fall is rather continuous and decomposition rate is very slow, which often resulted in the accumulation of unincorporated permanent humus layer, over the
surface of forest. The fact was true even of the temperate deciduous hardwood forests, where the low temperature often cause the formation of a perennial humus layer. It is generally held that the rate of decomposition of organic matter decreases in the northern latitudes and increases in the tropics (Lutz and Chandler 1947; Kittredge, 1948).

In contrast to the temperate floor, which is perennial by virtue of the continued presence of superterranean human layer, the floor in tropics appears to be short lived, as the superterranean 'I' layer gets mineralized either in a year or two. The cycle of floor in these deciduous forests begins by the periodic formation of I.-layer and ends with its complete biological decomposition which becomes complete in a year or two.

II. Classification of floor:

Leaf litter pattern and leaf structure are highly affected the form of floor (Bhatnagar, 1968). Heatwole (1961) have provided an classic work on floor typology on structural basis in temperate forest. He studied litter layer for its physical characteristics and determined following classes.

Class I - Largely formed by woody objects which do not made continuous carpet on floor.

Class II - Consisting chiefly of flat type of leaf litter. showing small interstitial spaces.

Class III - Consisting of mostly curled or rolled type of leaf litter. forming large interstitial spaces.

Bhatnagar (1968) have first made an attempt on floor typology on the basis of structural features of leaf litter in tropical dry deciduous forests.
of Sagar. He studied leaf litter layer of floor and determined following floor classes.

   Class I - Multistratal floor which is four or more layers of leaves in thickness.

   Class II - Oligostralal floor consists of two or three layers of leaves in thickness.

   Class III - Unistratal floor which is one layer of leaves in thickness.

In the present work classification proposed by Bhatnagar (1968) was followed and above tree types of floor classes were observed in the forest stand. Similar studies have also made by Joseph (1977) in mixed dry deciduous forest of Sagar. (M.P.)

III. Distribution of leaf litter on substratum:

Pattern of leaf litter distribution was an important aspect and after the completion of distribution processes viz., Aggregation, Congregation and Stabilization final picture of forest substratum was emerged.

III A. Aggregation: Aggregation was the initial stage of distribution. Since, studied forest consisted of both winter defoliating and summer defoliating species. Hence, the litter layer gradually developed with aggregation of leaf litter on the substratum. The components of the leaf litter at aggregation were loosely held upon each other and larger interstitial spaces were found. The litter layer in this stage was found to be pure and homogenous.

III B. Congregation: Congregation followed the aggregation. In the congregation litter layer of a mixed forest gradually got its typical mixed
characters and pure, homogenous and uniformly distributed floor got congregate with litter of other species. Due to wind action lateral overlapping of various leaf litter occurred towards each other and floor became patchy, uneven and discontinuous.

III C. Stabilization: Consolidation or stabilization of litter on substratum occurred due to tree coppices, tiller of ground flora and topography. The stormy wind swept litter got stabilized by the above props. Topographic features of forest stand also assisted in the stabilization as the leaf litter had a tendency to settle and stabilize in depression.

Though summer stormy wind played efficient role on congregation and stabilization of floor, however, specific identity of the substratum in this forest stand was maintained by the leaf litter of tree species under which floor developed. Due to higher leaf litter production and tree density *Anogeissus pendula, Butea monosperma* and *Tectona grandis* were played important role in the emerging final picture of the floor.

In the present study leaf litter of *Anogeissus pendula* formed a carpet of uniform thickness. Due to low weighted, small sized leaves and higher density, leaf of this species easily distributed where as leaf size and weight of *Tectona grandis* was found to be higher so that leaf litter of this species was less affected by wind action. In the case of *Butea monosperma*, inspite of large sized leaves, the leaf litter of this species was moderating affected by wind storm. It was found that a large amount of leaf litter of this species stabilized by the tillers of *Cassia tora*, coppices of tree and accumulated in the depressions.
IV Accumulation:

Accumulation of litter on forest substratum is of great importance. The supply of soil nutrients is influenced by the amount of accumulated litter that decomposes in the forest soil. The accumulated litter serve as natural mulch which reduces evaporation. This mulching effect can be critical during droughts when soil moisture becomes limited particularly in open forests or plantations where the canopies are not yet close (Loria, 1999).

Individual floor types attain levels of thickness which are characteristic of them and the ranges fluctuate within the limits. The thickness of leaf litter layer of floor is higher for those species which have flat leaf litter and form multistratal floors. Values of next order are attained by those species which form oligostratal floors whereas the values of least thickness are obtained by species forming unistratal floors (Bhatnagar, 1968).

In the present work it was found that thickness of floor was directly related to the type of leaf litter, climatic condition, species composition, topography etc. The ranges of thickness for multistratal floor of *Tectona grandis* varied from 8.5 to 14.5 cm. Leaf litter of *Butea monosperma* with *Anogeissus pendula* leaf litter formed oligostratal floor of 4.5 to 7.0 cm thickness. Leaf litter of *Anogeissus pendula* formed unistratal floor of 1.5 to 3.0 cm thickness.

The high values (4.8 to 18.5 cm) of the thickness of litter layer was found for separate species in tropical deciduous forest of Sagar by Bhatnagar (1968).
In the tropical deciduous forest thickness of litter layer and fragment layer were found to range between 2.5 and 4.0 cm and 5.0 and 6. cm respectively (Joseph, 1977). The high values (3 to 7 cm) of thickness of humus layer of floor in temperate forests recorded due to slow rate of decomposition (Lutz and Chandler, 1947 ; Kittredge, 1948). In tropical rain forests, the leaf fall was rather continuous but decomposition rate was fast which results in low accumulation of humus layer (Mohr and Van Baren, 1959).

Thus pattern of accumulation of forest floor was a result of many factors: productivity, species composition, decay resistance, topography, climate and age of the stand. (Gosz et al., 1976).
I. Soil physical properties

1A. Soil texture and Bulk density:

Soil texture refers to percentage by weight of each of three mineral fractions sand, silt and clay. Textural analysis and bulk density of soil under the canopies of dominant tree species are presented in table 20. The general textural classification for the soil was sandy clay to sandy clay loam. There was not much difference in bulk density of soil under different tree species. The bulk density of soil under *Anogeissus pendula* and *Butea monosperma* was slightly higher than soil under *Acacia catechu* and *Tectona grandis*. It was found that under the canopies of *Anogeissus pendula* and *Butea monosperma* the textural class was sandy clay while under *Tectona grandis* and *Acacia catechu* the soil textural class was sandy clay loam.

It is evident from the table 16 that in general the soil of studied forest had higher percentage of sand followed by clay and silt. Similar observation has been reported by Singh *et al.* (1983) in the seventeen forest sites of Bundelkhand region. Roy (1996) studied productivity of *Hardwickia binata* based silvipasture in Bundelkhand region. They reported that in general for the surface layer of all microsites the textural classification was sandy clay loam. The deeper layer in all the microsites exhibited a sandy clay texture.

1B. pH and electrical conductivity:

The pH and electrical conductivity of soil under canopies of dominant tree species at different depths are presented in table 21. There was only a slight difference in pH under different tree species. The soil of studied
Table 16: Soil textural analysis and Bulk density under canopies of dominant tree species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Bulk density (g/cc)</th>
<th>Soil texture (%)</th>
<th>Textural class</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia catechu</em></td>
<td>1.27</td>
<td>57.1</td>
<td>12.5</td>
</tr>
<tr>
<td><em>Anogeissus pendula</em></td>
<td>1.33</td>
<td>49.6</td>
<td>10</td>
</tr>
<tr>
<td><em>Butea monosperma</em></td>
<td>1.23</td>
<td>46.4</td>
<td>15</td>
</tr>
<tr>
<td><em>Tectona grandis</em></td>
<td>1.11</td>
<td>53.9</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Forest was acidic in reaction. There was not definite trend of increase or decrease in pH at different depths under a particular tree species. The electrical conductivity of soil under canopies of *Anogeissus pendula* and *Butea monosperma* was higher as compared to the soils of under *Tectona grandis* and *Acacia catechu*.

Maximum (0.064 m mhos/cm) electrical conductivity was reported under *Anogeissus pendula* in the upper layer (0-15 cm), while minimum (0.023 m mhos/cm) electrical conductivity was found to be under *Acacia catechu* in the middle layer (15-30 cm). As in pH, no definite trend of increase or decrease in electrical conductivity was observed at different depths.

The pH has indirect effect on plant growth by influencing nutrient release by weathering, the solubility of all materials in the soil and the amount of nutrient ions stored on the cation exchange sites (Roy 1996). Studies carried out in seventeen forest sites of Bundelkhand region by Singh et al. (1983) revealed that the soils of these sites are slightly acidic in
reaction, pH ranging from 5.6 to 6.8 which is quite favourable for nutrient availability. They also reported that *Anogeissus pendula* and *Tectona grandis* are found to occur in soils having a pH of 6.3 and 6.5, respectively. Yadav and Sharma (1968) also reported that teak bearing area have acidic soil in Madhya Pradesh. This supports observation obtained in the present study.

Table 17: pH and electrical conductivity (EC) of soil under canopies of dominant tree species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Depth (cm)</th>
<th>Physical Characteristics</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pH</td>
<td>EC (mhos cm)</td>
<td></td>
</tr>
<tr>
<td><em>Acacia catechu</em></td>
<td>0-15</td>
<td>6.7</td>
<td>0.033</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-30</td>
<td>5.8</td>
<td>0.023</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30-45</td>
<td>6.1</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td><em>Anogeissus pendula</em></td>
<td>0-15</td>
<td>6.4</td>
<td>0.064</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-30</td>
<td>6.6</td>
<td>0.043</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30-45</td>
<td>6.5</td>
<td>0.053</td>
<td></td>
</tr>
<tr>
<td><em>Butea monosperma</em></td>
<td>0-15</td>
<td>6.4</td>
<td>0.056</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-30</td>
<td>6.3</td>
<td>0.053</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30-45</td>
<td>6.0</td>
<td>0.047</td>
<td></td>
</tr>
<tr>
<td><em>Tectona grandis</em></td>
<td>0-15</td>
<td>6.4</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15-30</td>
<td>6.5</td>
<td>0.024</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30-45</td>
<td>6.5</td>
<td>0.029</td>
<td></td>
</tr>
</tbody>
</table>

II. Chemical properties of soil:

There are, of course, many factors which control the productivity of forest. The fertility level of soil is one of such major factor. It is, therefore, essential to take into consideration the fertility levels of soil under canopies of dominant tree species. These are discussed below.
IIA. Available Nitrogen:

The data presented in table : 18 shows that the amount of available nitrogen in soil was in the low range. Maximum amount of available nitrogen (247.74 kg/ha) was observed under canopy of *Butea monosperma* in the upper layer (0-15 cm) and minimum amount of available nitrogen (163.34 kg/ha) was found to be under *Acacia catechu* in the middle layer (15-30 cm). Maximum average available nitrogen (221.61 kg/ha) was recorded under *Butea monosperma* followed by *Tectona grandis* (196.29 kg/ha), *Anogeissus pendula* (187.11 kg/ha) and *Acacia catechu* (178.84 kg/ha).

Thus, values of average available nitrogen were show a wide variation under various tree species.

Vertical distribution of available nitrogen was not exhibit any trend with increasing depth (figure : 10). The potential rate of nitrogen use by growing plants generally exceeds the rate at which nitrogen becomes available (Ensminger and Pearson, 1950). Thus, the amount of nitrogen in the soil is in the low range. The absorption rate of nitrogen by plants in growing phase is not always the same and is subject to interaction of a number of ecological and physiological factors (Roy, 1996). So there was no definite trend of variation in available nitrogen with respect to depth.

Hazra (1981) reported that in general soils of Bundelkhand are poor in nitrogen. Mannikar (1981) also studied fertility status of Bundelkhand region and observed that the red soils of this region are low to medium high in nitrogen. Singh *et al.*, (1983) studied soil characters with respect to forest species in Bundelkhand region. They observed that soil supporting
Acacia sps. was relatively very poor in nitrogen, CEC and exchangeable calcium while Anogeissus pendula and Tectona grandis was found to be in soil relatively rich in nitrogen.

Table 18: Distribution of available nitrogen (kg/ha) under canopies of dominant tree species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Depth (cm)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-15</td>
<td>15-30</td>
<td>30-45</td>
<td>Average</td>
</tr>
<tr>
<td>Acacia catechu</td>
<td>172.48</td>
<td>163.34</td>
<td>200.74</td>
<td>178.84</td>
</tr>
<tr>
<td>Anogeissus pendula</td>
<td>197.56</td>
<td>188.16</td>
<td>175.61</td>
<td>187.11</td>
</tr>
<tr>
<td>Butea monosperma</td>
<td>247.74</td>
<td>206.97</td>
<td>210.11</td>
<td>221.61</td>
</tr>
<tr>
<td>Tectona grandis</td>
<td>206.29</td>
<td>191.29</td>
<td>191.29</td>
<td>196.29</td>
</tr>
<tr>
<td>Average</td>
<td>206.02</td>
<td>187.44</td>
<td>194.43</td>
<td>195.96</td>
</tr>
</tbody>
</table>

II B. Organic Carbon:

Organic matter has a marked effect on physico-chemical and biological properties of soils and on plant nutrition. The data presented in table: 25 indicates that the average values of organic carbon content, in soil, showed a wide variation under the canopies of different dominant tree species, varying from 0.45 - 0.95 per cent. Soil under canopy of Tectona grandis contained maximum percentage (0.95 per cent) of organic carbon content while minimum percentage (0.45 per cent) of organic carbon content was found to be under Acacia catechu. Soil supporting Anogeissus pendula and Butea monosperma had 0.74 and 0.57 per cent organic carbon content, respectively.
Fig. 10: Distribution of available nitrogen (kg/ha) under canopies of dominant tree species at three depths. (AC = Acacia catechu, AP = Anogeissus pendula, BM = Butea monosperma, TG = Tectona grandis)

Fig. 11: Percentage of organic carbon under canopies of dominant tree species at three depths. (AC = Acacia catechu, AP = Anogeissus pendula, BM = Butea monosperma, TG = Tectona grandis)
This wide variation in organic carbon content may be due to amount of litter accumulating at soil surface under these tree species.

Organic carbon content was highest at upper layer and exhibited a decreasing trend with increasing depth (figure: 11). The gradual decrease in organic matter with respect to depth was also observed by Yadav and Sharma (1968) in sal and teak forest of M.P., Agarwal and Tripathi (1977) in some typical soil profiles of U.P., and Gupta et al. (1991) in some north-western Himalayan soils. Singh et al. (1983) have studied soil characters of forests of Bundelkhand. They reported that soils supporting *Anogeissus pendula*, *Anogeissus latifolia* and *Tectona grandis* were rich in organic matter while, *Acacia catechu* was found to be on sites having relatively low organic matter.

Jeyamala and Soman (1999) reported that improvement in the organic carbon content under the tree canopies is due to the increased inputs of tree litter. Pratap et al. (1990) have also confirmed this and stated that due to recycling of organic matter through litter fall and under story vegetation cover, surface soil show more organic carbon. Prasad and Mishra (1985) have reported that in a mixed forest, teak alone produce 1/3 of the total production of litter which adds to the forest floor and enrich the organic content of the soil.

**II.C. Available Phosphate (P$_2$O$_5$ kg/ha)**

Phosphorus, the key to the life, is directly involved in most life processes. Data presented in table: 26 reveals that the available phosphate in the soil was in the low range and maximum available phosphate
Table 19: Percentage of organic carbon under canopies of dominant tree species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Depth (cm)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-15</td>
<td>15-30</td>
<td>30-45</td>
</tr>
<tr>
<td>Acacia catechu</td>
<td>0.50</td>
<td>0.48</td>
<td>0.38</td>
</tr>
<tr>
<td>Anogeissus pendula</td>
<td>0.94</td>
<td>0.68</td>
<td>0.61</td>
</tr>
<tr>
<td>Butea monosperma</td>
<td>0.63</td>
<td>0.56</td>
<td>0.53</td>
</tr>
<tr>
<td>Tectona grandis</td>
<td>1.37</td>
<td>0.79</td>
<td>0.71</td>
</tr>
<tr>
<td>Average</td>
<td>0.86</td>
<td>0.62</td>
<td>0.55</td>
</tr>
</tbody>
</table>

(22.5 kg/ha) was occur under *Tectona grandis* in the upper layer (0-15 cm) while, under *Acacia catechu* minimum value (4.5 kg/ha) was recorded in the lower layer (30-45 cm).

Vertical distribution of available phosphate was not show any trend with increasing depths (figure : 12). Maximum amount of average available phosphate (16.5 kg/ha) was recorded under *Tectona grandis* followed by *Butea monosperma* (15 kg/ha), *Anogeissus pendula* (13.5 kg/ha) and *Acacia catechu* (9 kg/ha).

The available phosphorus varies with solubility, amount of solution present and the distance phosphate ion must move to reach the plant root that will absorb it. These three variables are in turn dependent on several other factors (Thompson and Troch 1985). Hazra (1981) reported that in general soils of Bundelkhand are low to medium in phosphate. Mannikar (1981) also studied fertility status of Bundelkhand soils and observed that red soils of the region are low to medium in phosphorus.
Table 20: Distribution of available phosphate (kg/ha) under canopies of dominant tree species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Depth (cm)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-15</td>
<td>15-30</td>
<td>30-45</td>
<td>Average</td>
</tr>
<tr>
<td>Acacia catechu</td>
<td>13.5</td>
<td>9.0</td>
<td>4.5</td>
<td>9.0</td>
</tr>
<tr>
<td>Anogeissus pendula</td>
<td>18.0</td>
<td>9.0</td>
<td>13.5</td>
<td>13.5</td>
</tr>
<tr>
<td>Butea monosperma</td>
<td>18.0</td>
<td>18.0</td>
<td>9.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Tectona grandis</td>
<td>22.5</td>
<td>13.5</td>
<td>13.5</td>
<td>16.5</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>18.00</strong></td>
<td><strong>12.375</strong></td>
<td><strong>10.125</strong></td>
<td><strong>13.5</strong></td>
</tr>
</tbody>
</table>

II D. Available Potash (K₂O Kg/ha):  

Potassium is the third most likely nutrient element to limit plant growth. The data on soil available potash is presented in table 21 indicates that the upper layer (0-15cm) of soil always contained more available potash than that of next two layers (figure 12). In the upper layer (0-15 cm) maximum value (303.57 kg/ha) was recorded under *Anogeissus pendula* while, minimum value (134.92 kg/ha) was found to be under *Butea monosperma* in lower layer (30-45 cm).

The values of available potash as show in table 21 indicates that amount of available potash was in the medium range. Maximum average amount (258.59 kg/ha) was recorded under *Anogeissus pendula* followed by *Tectona grandis* (224.86 kg/ha), *Acacia catechus* (202.38 kg/ha) then in *Butea monosperma* (168.65 kg/ha). The availability of potassium depends on the release of non-exchangeable potassium. Exchangeable
Fig. 12: Distribution of available phosphate (kg/ha) under canopies of dominant tree species at three depths. (AC = Acacia catechu, AP = Anogeissus pendula, BM = Butea monosperma, TG = Tectona grandis)

Fig. 13: Distribution of available potash (kg/ha) under canopies of dominant tree species at three depths. (AC = Acacia catechu, AP = Anogeissus pendula, BM = Butea monosperma, TG = Tectona grandis)
potassium ions can not move to plant roots unless they are replaced by other cations on exchange sites (Thompson and Troeh, 1985).

Hazra (1981) found that soils of Bundelkhand region are medium to high in potash. Mannikar (1981) also studied fertility status of Bundelkhand soils and reported that red soils of this region are low to medium high in potash. According to Singh et al., (1983) fertility of forest Table 21: Distribution of available potash (K₂O Kg/ha) under canopies of dominant tree species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Depth (cm)</th>
<th></th>
<th></th>
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<td>269.84</td>
<td>202.38</td>
<td>258.59</td>
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<tr>
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<td>168.65</td>
<td>134.92</td>
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<td>269.84</td>
<td>202.38</td>
<td>202.38</td>
<td>224.86</td>
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<td>252.97</td>
<td>210.81</td>
<td>177.08</td>
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soils, with respect to potassium, was higher than most of the cultivated areas of Bundelkhand region. Soils of all these forest can be rated as medium to high in available potassium.

Changes in soil potassium under different silvicultural system were studied by Gupta et al. (1990) in silver fir and spruce forests of Himachal Pradesh. They observed that soils of this region were sufficiently rich in soil potassium and soil potassium decrease with increasing soil depth in all sites and management systems. Depth correlation of soil potassium confirmed decreasing level with increasing soil depth. This is generally caused by the pattern of soil humus distribution on the one hand and
leaching effect on the other. Soil nutrient concentration was more in upper layer and decreased down the soil profile (Gupta and Rorison, 1975). It is likely that more potassium released from the soil for absorption by the root and microbes etc. and due to biochemical activities of upper layer. The decreased soil potassium in lower layer may have been caused by lack of activity, low root demand and low moisture (Gupta et al. 1990).
This study in an out come of intensive explorations and regular field trips of the forest sites through all the seasons. The forest block surveyed were lanka beet, lotna beet, singpura beet and kariparar beet. Frequent inspections of these area yielded a total of 71 plant species which were appropriately, assigned to their life-form classes and other plant-form viz. Growth and migrule forms and sociability classes. The biological spectrum and other qualitative assessments of plant forms are recorded in table 26.

This appears to be the first to record the floristies of the local forest sites by means of the biological spectrum.

The life-form classes viz. Phanerophytes, Chamaephytes, Hemicryptophytes. Geophytes and therophytes were numerally presented in the forest area. The percentage of these life-form classes, as worked out can be documented as below:

- Phanerophytes : 36.6%
- Chamaephytes : 21.1%
- Hemicryptophytes : 7.0%
- Geophytes : 5.6%
- Therophytes : 29.6%

Thus the region seems to be dominated by phanerophytes. Therophytes were proxime accessit. In other words a peupres two third of the total plant species gathered under these two life form classes.

The majority of the species were erect 39.4% and branched annuals (16.9-42.4%) with dissemination of their seeds mostly by wind or water (39.4%) or through animals (12.7%) or both (52.1%). Nearly all the
annual plant species were found growing either isolated (36.6%) or forming a small group (49.2%) whereas the perennials (63.4%), most of which were either trees shrubs, climbers or grass were going in close associations and thereby forming either open, close or colonies. The biennials contributed poorly with (5.6%) of their shares in the total vegetation.

Stratification:

The concept of stratification is of obvious importance in understanding the structure of the forest area. The stratification of the vegetation may range from two layer a herb layer at ground level and canopy of the tree layer at top level to a more complicated arrangements with a herb layer. Several shrub and sapling layers and the overall top canopy of the tree layer.

The forest is usually divided into five layers viz., A.B.C.D and E. (Richards, 1952). These multistoried structure of the vegetation as constituted by the process of stratification and ultimately recognised as different layers in the stand are:

A-Layer or Emergent Layer: The tier is otherwise were called the ‘Eco-dominant tier’ ‘Top Layer’ or the ‘Crown Canopy’. The trees forming this layer were generally stunted in their growth and they hardly attained a height of 10m or more. The trees were scattered in the area without any overlapping of crowns. Some of the common trees constituting this top tier were: Ficus benghalensis, Ficus religiosa, Holoptelia integrifolia, Salinaria malabarica, Terminalia arjuna and terminalia tomentosa.

B-Layer or Middle Layer: This layer is also known as ‘Co-dominant
Tier’. Sub-canopy or ‘Under storey’. Some of the plants falling under this layer of stratification developed a close colony. The common component species constituting the tier were: *Acacia catechu, Albizzia lebbeck, Anogeissus, Anogeissus pendula, Butea monosperma, Diospyros melanoxylon, Laneea coromandelica, Mitragyna parviflora, Tectona grandis* etc.

**C-Layer or Lower Layer**: This tier is also known as ‘Lower storey’, ‘Lower tier’ or ‘Lower canopy’. Plants providing shapeliness to this tier were customarily under trees, large shrubs and top climbers including some twiners. They can be listed as: *Vitex negundo, Zizyphus mauritiana* etc.

**D-Layer or Shrub Layer**: The forms of vegetation composing this fourth tier of stratification were extensively shrubs or bushes. Many of them were armed with thorns or spines. Some of the vulgar plant species contriving this layer were: *Flacourtia ramontchi* etc.

**E-Layer or Ground Layer**: This last layer of the stratification is also known as ‘Field layer’ or the ‘Ground flora’. The vegetation of this layer is rightly been considered as ‘Guardian of the Soil’. It is actually the vestment of the earth. The tier is framed of a few erect, Sub-erect, prostrate or tufted herbs and under shrubs. Creepers, trailers and the grass also subscribe in making up this fifth and the last tier of the stratified vegetation. Some of the plant species ordinarily contained in this layer can be listed under sub-heads as below:

(a) **Under Shrubs**: *Barlaria priontis* etc.

(b) **Erect and Suberect Herbs**: *Achyranthus aspera, Cassia tora, Digitaria muricata, Sida cordifolia, Tridex procomhans* etc.
(c) **Diffuse Herbs**: *Elytraria acaulia, Tribulus terrestris* etc.

(d) **Creepers and Trailers**: *Lathyrus aphaca* etc.

(e) **Sedges**: *Cyperus nivens, Fimbristylis dichotoma* etc.

(f) **Grass**: *Aphloca mutica, Brachiaria raptans, Cenchrus ciliaris, Cynodon dactylon, Dactyloctenium aegyptium, Eragrasis ciliaris, Heteropogon contortus* etc.
Table 22: Biological spectrum and other qualitative assessments of the component species stating their habit, life form, growth form and migrule form, sociability class and the stratification in the flora of research site.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of the Family of the Component Species</th>
<th>Habit</th>
<th>Life Form</th>
<th>Growth Form</th>
<th>Migrule Form</th>
<th>Sociability Class</th>
<th>Stratification Class</th>
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<td>S₂</td>
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<td>Ch</td>
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<td>S₂</td>
<td>E</td>
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<td>Ch</td>
<td>p-b-ps</td>
<td>D₁-D₂</td>
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<td>Ch</td>
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<td>D₁-D₂</td>
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<td><em>Euphorbia hirta</em>, Linn.</td>
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<td><em>Phyllanthus urinaria</em>, Linn.</td>
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<td><em>Ricinus communis</em>, L.inn.</td>
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<td>Ch</td>
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<td>D₁-D₃</td>
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<td><em>Ficus benghalensis</em>, Linn.</td>
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<td><em>Ficus religiosa</em>, Linn.</td>
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<td>e-b</td>
<td>D₂-D₄</td>
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<tr>
<th>Sr. No.</th>
<th>Name of the Family of the Component Species</th>
<th>Habit</th>
<th>Life Form</th>
<th>Growth Form</th>
<th>Migrule Form</th>
<th>Sociability Class</th>
<th>Stratification Class</th>
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<td><em>Aristida adscensionis</em>, Linn.</td>
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<td><em>Brachiaria reptans</em>, (Linn.) Gardn &amp; Hubb.</td>
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<td><em>Cenchrus ciliaris</em>, Linn.</td>
<td>P</td>
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<td>e-t</td>
<td>D₂-D₅</td>
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<td><em>Chysopogon fulvus</em>, (Spreng.) chiov.</td>
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<td>He</td>
<td>e-t</td>
<td>D₁-D₂</td>
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<td></td>
<td><em>Cynodon dactylon</em>, (Linn.) pers.</td>
<td>P</td>
<td>G</td>
<td>p</td>
<td>D₁-D₂</td>
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<td><em>Dactylolcetest aegyptium</em>, (Linn.)</td>
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<td><em>Beauv.</em></td>
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<td>D₁-D₂</td>
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<td><em>Eragrostis diarrhena</em>, (Schult.) Stend.</td>
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<td>D₁-D₂</td>
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<td><em>Eragrostis pilosa</em>, (Linn.) Beau.</td>
<td>A</td>
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<td>D₁-D₂</td>
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<td></td>
<td><em>Ischilema laxum</em>, Hack.</td>
<td>P</td>
<td>He</td>
<td>e-t</td>
<td>D₁-D₅</td>
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<td><em>Panicum psilopodium</em>, Trim.</td>
<td>P</td>
<td>He</td>
<td>p-(e)</td>
<td>D₂</td>
<td>S₁</td>
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<td><em>Paspalidium flavidum</em>, (Retz.) Camus</td>
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<td>Ch</td>
<td>p</td>
<td>D₁-D₂</td>
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<td><em>Schima nervosum</em>, (Willd.) Strapf.</td>
<td>P</td>
<td>G</td>
<td>e-rh</td>
<td>D₁-D₂</td>
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<td><em>Setaria glauca</em>, (Linn.) Beauv.</td>
<td>A-P</td>
<td>Ch</td>
<td>p-(e)</td>
<td>D₁</td>
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<td><em>Setaria tomentosa</em>, (Roxb.) kunth.</td>
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<td>D₁</td>
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<td><em>Setaria verdicillata</em>, (Linn.) Beauv.</td>
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</tbody>
</table>
**Legends:**

Habit: A = Annual, P = Perennial, Bi = Biennial.

Life forms: Ph = Phanerophytes, Th = Therophytes, Ch = Chaemophytes.

G = Geophytes, He = Hemicryptophytes.

Growth forms:

- e = Erect
- p = Prostrate
- b = Branched
- t = Tussock
- cl = Climber
- tw = Twinner
- tr = Trailer
- rh = Rhizomatous
- ps = Pseudorosette

Legends within parenthesis indicate probability.

Migration forms:

- $D_1 = \text{Dissemination by Wind or Water.}$
- $D_2 = \text{By Animal or Man.}$
- $D_3 = \text{By Mechanical Proulsion.}$
- $D_4 = \text{Only by Gravity.}$
- $D_5 = \text{By Vegetative Propagation.}$

Sociability class:

- $S_1 = \text{Isolated}$
- $S_2 = \text{Small group}$
- $S_3 = \text{Close colony}$
- $S_4 = \text{Large close carpet}$
- $S_5 = \text{Large open carpet}$

Stratification:

- A = Emergent layer
- B = Middle layer
- C = Lower layer
- D = Shrub layer
- E = Ground layer
PAPAVERACEAE

1. Argemon mexicana. Linn (Pili Katai) Herb.
   - Yellow latex is used externally in conjunctivitis and skin diseases.
   - Roots are used in chronic skin diseases.
   - Juice of the plant is prescribed for the treatment of Jaundice.
   - Roots used for Totem.
Loc.: Lotna (M.P.).

CRUCIFERAE

   - Oil obtained from the seed is used for the preparation of various dishes.
   - Oil cakes are given to cattle for feeding.
   - The oil is orally administrated to the cattle for intestinal worms.
   - The oil mixed with kapoor is externally applied to gout.
   - The leaves and shoots are used as vegetables.
Loc.: Lotna (M.P.).
Ethn. dist.: Bundelkhand, Uttar Pradesh (Singh and Mahashwari, 1985), Vyasi Valley (Dhyani and Sharma, 1987).
   - Decoction of the twigs prepared in mustard oil is tropically applied in
     toothache and rheumatic pain.
   - The fruits are picked and used to kill intestinal worms.

Loc.: Lotna (M.P.).
Ethn. dist.: Bundelkhand.

   - The seeds are eaten.
   - Extract of the leaves is tropically applied in itch. The juice of the
     leaves is used in earache.

Loc.: Lotna (M.P.).
Ethn. dist.: Bundelkhand, Bihar (Tarafer and Chaudhuri, 1981),
Maharashtra (Shah et. al., 1983), Meghalaya (Neogi et. al., 1989), Vyasi
Valley (Dhyani and Sharma, 1987).

**BIXINEAE**

5. *Flacourtia indica*, Merr. (Katai) Shrub.
   - Decoction of the bark is used to treat the scabies and other skin diseases.
   - The roots are used as an antidote to snake bite.
   - The fruits are eaten.

Loc.: Lotna (M.P.).
Ethn. dist.: Bundelkhand, Madhya Pradesh (Jain 1963), Vyasi Valley
(Dhyani and Sharma, 1987), Uttar Pradesh (Siddiqui et. al., 1989).

**DIPTEROCARPACEAE**

   - The wood is used for house building materials.
- The twigs are used as tooth sticks.
Loc.: Lotna (M.P.).


MALVACEAE

7. Salinia malabaricum. Schott Meletem. (Semal) Tree.
- The cotton obtained from the fruits is used for stuffing beds and pillows.
- The plants are used as tonic.
- The stem bark is pounded to make a paste and applied on pimples.
Loc.: Lotna (M.P.).
Ethn. dist.: Bundelkhand, Assam (Battacharjee et al., 1980), Himachal Pradesh (Kanpur, 1986).

- The plant is used as an antidote to snake bite.
- Powdered root are used for the treatment of leucorrhoea.
Loc.: Lotna (M.P.).

- Fibres obtained from the stems are used as ropes for tying purpose.
- Juice of the roots is applied to the cuts and injuries for quick healing of the wound.
- The roots are used in the treatment of leucorrhoea.
Loc.: Lotna (M.P.).
Ethn. dist.: Bundelkhand, West Bengal (Das et. al., 1983), Tamilnadu (Banerjee and Banerjee, 1986). Assam (Tiwari et. al., 1980), Himachal Pradesh (Kapur, 1986), Bihar (Tarafdar and Chanduri, 1986).

LINEAE

- Oil is obtained from the seeds.
- The seeds are used in waistache.
- Oil cakes are used as manure.

Loc.: Lotna. (M.P.).

Ethn. dist.: Bundelkhand, North eastern India (Island, 1986), Vyasi Valley (Dhyani and Sharma, 1987).

ZYGO PHYLLEAE

- Infusion of the fruits powdered and boiled in water is used in Jaundice and other liver ailments.
- The powdered fruits alongwith milk are recommended for oral administration during Spermatorrhoea.
- The fruits are used to treat leucorrhoea.

Loc.: Lotna (M.P.).

Ethn. dist.: Bundelkhand, Gujrat (Gopal and Shah, 1985), Dhasan Valley (Saxena and Vyas, 1983). Himanchal Pradesh (Kapur, 1986).

- The leaves are used as vegetables.
- The plant is used as an antidote to snake bite.
- The leaves are used in dysentary.
- The seeds are eaten.
- Expressed juice of the leaves is applied in cuts to stop bleeding and for healing.
- The plant is used to cure scurvy.

Loc.: Lotna (M.P.).

Ethn. dist.: Bundelkhand, West Bengal (Das et. al., 1983), Himachal Pradesh (Kapur, 1986), Vyas Valley (Dhyani and Sharma, 1987), Maghalaya (Neogi et. al., 1989), Assam (Hajra and Baishya, 1981), Dhasan Valley (Saxena and Vyas, 1983), Maghalaya (Rao, 1981).

- Expressed juice of the underground bulbous part of the plant is prescribed for oral administration as a tonic.
- The leaves are cooked and eaten as vegetables.

Loc.: Lotna. (M.P.).

Ethn. dist.: Bundelkhand, Assam and Arunanchal Pradesh (Baruah and Sharma, 1987).

**RUTACEAE**

- Pulp of the half riped fruit mixed with the fruit juice of *Ficus benghalen*
  - sis. Linn. is provided orally alongside whey in stomachache and dysentry.
- Powdered fruits are used to cure gastro-intestinal problems.
- The leaves of the plant are offered to God ‘Shiva’.
- Pulp of the fruits is eaten and also used as a drink with sugar.

Loc.: Lotna. (M.P.)

Ethn. dist.: Bundelkhand, Orissa (Saxena et. al., 1981), Andman and Nicobar Island (Bhargava, 1981), Himanchal Pradesh (Kapur, 1986),
Calcutta (Chakravarty, 1975), Madhya Pradesh (Jain, 1965). Vyasi Valley (Dhyani and Sharma, 1987).

**BURSERACEAE**


- Decoction of the stem bark is used during cough and cold.
- Gum of the plant is externally applied on itch eczema.

Loc.: Lotna (M.P.).


**MELIACEAE**


- Fresh twigs are used as toothsticks for brushing teeth.
- The wood is used for making furniture and agricultural implements.
- The leaves are used for protection of clothes from insects.
- Oil extracted from the seeds is used in skin diseases and rheumatism.
- Decoction of the powdered bark or leaves is effective in skin diseases.

Loc.: Lanka beet (M.P.).


**RHAMNACEAE**


- The stem is powdered and applied in septic wounds.
- Ripe fruits are eaten.
- Expressed juice of the leaves is used in dysentery.
- The wood is used for making agricultural implements and as timber.
Loc.: Lotna (M.P.).
Ethn. dist.: Bundelkhand.

**AMPELIDEAE**

- The fresh stem is pounded and the poultice is externally applied on bone fracture.
Loc.: Lotna (M.P.).
Ethn. dist.: Bundelkhand.

**ANACARDIACEAE**

- The fruits are eaten and also pickled.
- The wood is used as timber and also used for making furniture and agricultural implements.
- Decoction of the bark is orally administered during dysentery.
- The leaves are used as an antidote to scorpion sting.
- The gum is used to treat scabies. The cotyledons are dried and powdered along with dried fruits of *Eugenia jambolana* used for the stomach disorders.
- Worshipped as sacred plant.
- The inflorescence used for totem.

**LEGUMINOSAE**

20. *Acacia catechu*. Willd. (Khair) Tree.
- Cutch is obtained from heart wood of the plant.
- The wood is used for making agricultural implements also used as
timber.
- The sap is used for dyeing ropes and fishing nets.
- The leaves are used in skin diseases.
Loc. : Lotna (M.P.).


- The leaves are used in the treatment of night blindness.
- The leaves are used as an antidote to snake bite and scorpion sting.
Loc. : Lotna (M.P.).

Ethn. dist. : Bundelkhand, Calcutta (Chakravart, 1975).

22. Bauhinia variegata. Linn. (Kachnar) Tree.
- Buds and flowers are used as vegetables.
- Decoction of the bark is used in skin diseases and piles.
- The powdered floral buds are provided for oral administration in diarrhoea.
Loc. : Lanka beet (M.P.).

Ethn. dist. : Bundelkhand, Uttar Pradesh (Siddiqui et. al., 1989).

- An orange-red dye is obtained from the flowers for colouring purposes.
- The seeds are used as an antidote to snake bite.
- The flowers are boiled and the water is used for bathing as a prevention from smallpox and skin diseases.
- The gum is used in dysentery and ringworm disease.
- The roots are used on ‘Guru Purima’. 

111
- The wood is used in ‘Hawan’.
- The leaves are used to make plates locally known as ‘Dauna and Pattal’.
- Oil extracted from the seeds is used in skin diseases.
- A decoction of the flowers is used on boils and blisters, also useful is gonorrhoea.
- Fibres are obtained for tying purpose.


Ethn. dist. : Bundelkhand, Uttar Pradesh (Singh and Maheshwari, 1983). Vyasi Valley (Dhyani and Sharma, 1987), Uttar Pradesh (Siddiqui et. al., 1989).

- Pulp of the fruit is given to the cattle suffering from colic, cough and stomachache, also used as a purgative and provided in constipation, dysentery and diarrhoea.
- The fruit is used as an antidote to snake bite.
- The wood is used to make furniture.


25. Cassia tora, Linn. (Pumar) Herb.
- The seeds are powdered, mixed with mustard oil, applied on itch and eczema.
- The leaves are used as poultice and boils. Leaves are provided in
A close up view of flowering of *Cassia fistula*.

A close up view of *Butea monosperma* with flowering.
A close up view of *Lannea coromandalica* with fruiting.

A close up view of *Acacia leucophloeae* with fruiting.
night blindness. The leaves are worked as vegetables.

loc. : Lanka beet (M.P.).


26. Dalbergia sissoo, Roxb. (Shisham) Tree.
   - The leaves are pounded applied on eye in conjunctivitis.
   - The wood is used for making furniture, musical and agricultural implements.

loc. : Lanka beet (M.P.).

ETHN. DIST. : Bundelkhand, West Bengal (Das et. al., 1983). Uttar Pradesh (Singh and Maheshwari, 1985).

**CRASSULACEAE**

27. Anogeissus latifolia, Wall. (Dhaura Bakli) Tree.
   - Decoction of the skin bark is used in jaundice and disorders to stomach and liver.
   - The wood is used for making wheels of the cart and other agricultural implements.
   - The roots are used as an antidote to snake bite and scorpion sting.
   - The leaves are used as a colouring material in local tanneries.

loc. : Lotna (M.P.).


28. Anogeissus pendula, Edgw. (Kardhai) Tree.
   - Decoction of the powdered seeds is provided for oral administration in dysentery.
- The wood is used as fuel.

Loc. : Lotna and Lanka beet (M.P.).


- The powdered stem bark mixed with coconut oil is applied on burns.

- Decoction of the skin bark is used as a heart tonic in heart diseases.

Loc. : Lotna beet (M.P.).


**MYRTACEAE**

30. Eugenia jambolana. Lamk. (Jamun) Tree.

- The leaves are used in dysentery.

- Decoction of the stem bark is used in leucorrhoea.

- The fruits are eaten.

- Fruits are offered to God.

Loc. : Lotna (M.P.).

Ethn. dist. : Bundelkhand.

**RUBIACEAE**

31. Mitragyna parvifolia (Roxb.) Korth (Kaima) Tree.

- The wood is used for making musical and agricultural impliments.

  also used as timber.

- Fibres obtained from the plant are used to make ropes.

- Wood is used for worship in place of Sandal wood.

Loc.: Lotna (M.P.).
Ethn. dist. : Bundelkhand, Maharashtra (Sharma and LakhminarasaSimhan. 1986), Uttar Pradesh (Singh and Maheshwari. 1985).

**COMPOSITAE**

32. *Blumea lacera*, DC. (Kukrondha) Herb.
- Extract of the plant is provided orally in fever and bronchitis.
- The leaves are pounded and the paste is applied externally on eyes in conjunctivitis.
Loc. : Lotna (M.P.).
Ethn. dist. : Bundelkhand, Maharashtra (Shah et. al., 1983).

33. *Tridex procombens*, Linn. (Babuna) Herb.
- The plant is used as fodder because it increases lactation is the cattle.
- Expressed juice of the leaves is applied to the cuts and the paste of the same is applied to the septic wounds.
Loc. : Lotna bead (M.P.).

**SAPONACEAE**

- The oil obtained from the seeds is applied in ring worm.
- The oil is used for cooking and making soap.
- The oil cakes are used as manure.
- The flowers are edible and used as vegetables.
- The wood is used as timber and also used for making agricultural impliments.
Loc. : Lotna (M.P.).
Ethn. dist.: Bundelkhand, Uttar Pradesh (Siddiqui et al., 1989), Madhya Pradesh (Jain, 1963), Vyasi valley (Dhyani & Sharma, 1987).

**EBENACEAE**

- Fruits are eaten.
- Dried leaves are used to prepare Bidi.

Loc.: Lotna (M.P.).

Ethn. dist.: Bundelkhand, Madhya Pradesh (Jain, 1963).

**CONVOLVULACEAE**

- The plant is used as a blood purifier.
- The plants are provided to the cattle for feeding.

Loc.: Lotna (M.P.).

Ethn. dist.: Bundelkhand.

37. *Convolvulus pluricaulis* Chois. (Shankhpushp).
- The plants are used as brain tonic.

Loc.: Lotna (M.P.).

Ethn. dist.: Bundelkhand.

- The pounded plant is used as poultice in the treatment of superficial thrombophlebitis and boils.
- The whole plant or the seeds are used as a laxative.

Loc.: Orchha, (M.P.).

Ethn. dist.: Bundelkhand. Assam and Arunachal Pradesh (Baruah and Sharma, 1987), Bihar (Tarafdar and Chaudhari, 1981), Dhasan Valley (Saxena and Vyas, 1983), Uttar Pradesh (Siddiqui et al., 1989).
- The leaves are used in Asthma and bronchitis.

Loc. : Lotna (M.P.).


**ACANTHACEAE**

- The roots are used as poultice to the sores of cattle.
- The leaves are pounded and the paste is applied on wounds and
  noil diseases.

Loc. : Lotna (M.P.).


**VERBINACEAE**

41. *Tectona grandis*, Linn (Sagaun) Tree.
- The oil extracted from the fruits is used in Eczema and other skin
  diseases.
- The powdered seeds are also recomended for the same.
- The wood is used for making furniture and as timber.

Loc. : Orchha, (M.P.).

Ethn. dist. : Bundelkhand, Uttar Pradesh (Siddiqui et. al., 1989).
Maharashtra (Sharma and Lakshminarasimhan, 1986). Madhya Pradesh
(Jain 1963; 1965).

42. *Vitex negundo*, Linn. (Sambhalu) Shrub.
- Twigs are used for making baskets.
- The leaves are pounded and made into a paste. It is applied on the
  affected part caused by gout. also applied on forehead in headache.
- A decoction of the leaves is used on the swellings caused by external injuries.

Loc. : Lotna (M.P.).


LABIATAE

43. Lueca cephalotes. Spreng. (Gumbhi-myala) Herb.
- Extract of the plants is used in fever (Malaria).
- Ash of the leaves mixed with urine of horse is applied or head boils.

Loc. : Lotna (M.P.).

Ethn. dist. : Bundelkhand, Uttar Pradesh (Singh and Maheshwari, 1983), Bihar (Gupta, 1981), Tamilnadu (Banerjee and Banerjee, 1986).

NYCTAGINEAE

44. Boerhaavia diffusa. Linn. (Lal potherchata) Herb.
- Extract of the roots is used in Jaundice and other liver ailments.
- The leaves are cooked without salt and provided to the patient suffering from liver diseases.
- The leaves are used in Asthma.
- Powdered leaves mixed with mustard oil and applied on itch.

Loc. : Lotna Village (M.P.).

Ethn. dist. : Bundelkhand, Gujrat (Gopal and Shah, 1985), West Bengal (Das et. al., 1983), Tamilnadu (Banerjee and Banerjee, 1986), Vyasi Valley (Dhyani and Sharma, 1987), Maharashtra (Sharma and Lakshminarsimhan 1986), Calcutta (Chakravarty, 1975).
45. Achyranthus aspera, Linn. (Latjeera) Herb.
- The leaves are smoked in bronchial asthma.
- Aqueous extract of the roots is provided in dysentery.
- The roots are used as an antidote to snake bite.
- The roots are chewed to get relief from dental problems.
- The roots are used for totem.
Loc. : Lotna (M.P.).

46. Alternanthera sessilis, Br. (Bhut chara) Herb.
- The leaves are cooked as vegetables.
- Leaf-juice is used as an eye lotion in eye diseases.
Loc. : Lotna (M.P.).

47. Amaranthus spinosus, Linn. (Kantili-chorai) Herb.
- A decoction of the roots is used in dysmenorrhoea.
- The leaves are pounded and applied as poultice on absenses.
- The leaves are cooked as vegetable.
- The plants are used as fodder.
Loc. : Lotna (M.P.).
Ethn. dist. : Bundelkhand, Nilgiris (Abraham, 1981). West Bengal (Das


- The roots are pounded and made into paste.
- The paste is applied on eczema.
- The juice of the leaves is used in ring worm disease.

L.o.c. : Lotna. (M.P.).

Ethn. dist. : Bundelkhand, Uttar Pradesh (Siddiqui et al., 1989). West Bengal (Das et al., 1983).

**EUPHORBIACEAE**


- Juice of the plant is used to promote lactation in women.
- A decoction of the plant is used in the treatment of bronchial asthma.

- Expressed juice of the leaves is provided for oral administration to check vomiting.
- Expressed plant juice is used for the treatment of the dysentery in children.

L.o.c. : Lotna. (M.P.).

Ethn. dist. : Bundelkhand, Himanchal Pradesh (Kapur, 1986), Vyasi Valley (Dhyani and Sharma, 1997), Dhasan Valley (Saxena and Vyas, 1983), Tamilnadu (Banerjee and Banerjee, 1996), Madhya Pradesh (Jain, 1965). West Bengal (Das et al., 1983), Maharashtra (Shah et al., 1983).

50. *Euphorbia thymifolia*. Wall. (Chhoti dudhi) Herb.

- The plant extract is used for the treatment of piles.

L.o.c. : Lotna. (M.P.).
Ethn. dist. : Bundelkhand.

51. *Phyllanthus miruri*, Linn. (Bhui Amala) Herb.
- Expressed juice of the plant is used in the treatment of jaundice.


**URTICACEAE**

52. *Ficus benghalensis*, Linn. (Bargad) Tree.
- An infusion of the tips of aerial roots is provided to the child suffering from dysurtery.
- Latex is applied on boils. The fruits are eaten.
- A Sacred plant worshiped on the festival ‘Akshaya Tritiya’ by women.
- The wood is used to make house building materials and agricultural impliments.


53. *Ficus religiosa*, Linn. (Peepal).
- Wood of the sacred tree is used in “Hawan”.
- The tree is used for totem.


- The wood is used for making furniture and agricultural implements.
- A paste of the leaves is applied to ring warm disease.
- The paste of bark is used in the treatment of rheutism.
- The bark is used for totem.


**PALMEAE**

55. *Phoenix sylvestris*. Roxb. (Khajur) Tree.
- Brooms, baskets and toys are prepared with leaves.
- The fruits are eaten. The apex of the young plant locally known as ‘Gabha’ is eaten.
- Sap from the skin apex, ‘Nira’ is useful in asthma, it is also used for the preparation of ‘Gur’.


**CYPERACEAE**

- Washed rhizomes are dried and powered and used in the treatment of stomachache and diarrhoea.


Ethn. dist. : Bundelkhand.
A exclusive close up view of *Phoenix sylvestris* showing fruiting.
GRAMINEAE

- The plants are used as a fodder grass.
- The plant is pounded into a paste and applied to the wounds to check bleeding.
- The plant is offered to God.

Loc. : Lota. (M.P.).


- Sticks are used for making baskets.

Loc. : Orchha (M.P.).

Ethn. dist. : Bundelkhand, Maheshwari (Sharma and Lakshminarasimhan, 1986), Uttar Pradesh (Singh and Maheshwari, 1985).
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Botanical Name</th>
<th>Method of use/ Totems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acacia arabica</em>, Willd</td>
<td>Having tied a stone with thread and taken a round over the head of one suffering from malaria and tied it around the stem of <em>A. arabica</em> early in the morning either on sunday or wednesday malaria is said to be cured.</td>
</tr>
<tr>
<td>2.</td>
<td><em>Achyranthus aspera</em>, Linn.</td>
<td>(a) Piece of the roots of <em>A. aspera</em> are put in a piece of cloth and tied early in the morning on the wrist of a person suffering from malaria to cure it. (b) The plant of a <em>A. aspera</em> is pulled out with only one hand and the root tied with red thread is put around the waist of a lady suffering from delivery pains to get relief and early delivery.</td>
</tr>
<tr>
<td>3.</td>
<td><em>Argemon maxicana</em>, Linn.</td>
<td>A man is asked to run away seeing the root of <em>A. maxicana</em> shown to him either on sunday or wednesday and answering some questions according to the instruction given by the practioner to cure malaria.</td>
</tr>
<tr>
<td>4.</td>
<td><em>Ficus religiosa</em>, Linn.</td>
<td>A lady suffering from histeria is said to be cured if she invites the tree on saturday night, goes there early in the morning on sunday and takes three rounds of the tree.</td>
</tr>
<tr>
<td>5.</td>
<td><em>Holoptelia integrifolia</em>, (Roxb.) Planch.</td>
<td>A piece of the bark of <em>H. integrifolia</em> is tied on the arm early in the morning either on sunday or wednesday to the patient suffering from hydrocele.</td>
</tr>
</tbody>
</table>
### Table 24: Sacred Plants

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Botanical Name</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Aegle marmelos</em></td>
<td>Leaves used for worship of Lord Shiwa.</td>
</tr>
<tr>
<td>2.</td>
<td><em>Butea monosperma</em></td>
<td>Wood of the plant is used for “Mandap” during marriage ceremony. It is also used for Hawan during worship.</td>
</tr>
<tr>
<td>3.</td>
<td><em>Ficus benghalensis</em></td>
<td>Plant is worship on ‘Akshya Tritiya’.</td>
</tr>
<tr>
<td>4.</td>
<td><em>F. religiosa</em></td>
<td>Plant is worshiped to please Lord “Shani”.</td>
</tr>
<tr>
<td>5.</td>
<td><em>Ocimum sanctum</em></td>
<td>The plant and leaves are believed sacred and worship daily by the rural people.</td>
</tr>
</tbody>
</table>
Table 25: Festivals of Plants

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Botanical Name</th>
<th>Method of use/ name of Festival</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acacia arabica</em> Willd</td>
<td>The spiny and dried branches of <em>A. arabica</em> are decorated with different coloured flowers. Various fruits are also offered by girls to it on the occasion of the festival <code>Mamulian</code> in the month of <code>Bhadrapad</code>.*</td>
</tr>
<tr>
<td>2.</td>
<td><em>Butea monosperma</em> Kuntze.</td>
<td>On the last day of the month of <code>Asharh</code>* the fibres obtained from the roots of <em>Butea monosperma</em> (locally called <code>Bakonda</code>), are tied on the wrist of the village people as <code>raksha</code> mainly by the local Brahmins on <code>Guru Purnima</code>.*</td>
</tr>
</tbody>
</table>
| 3.      | *Ficus benghalensis* Linn.      | (a) The tree is worshipped by the women in the memory of `Sati Savitri` on the occasion of `Akshaya Tritiya` celebrated in the month of `Jyeshtha`*.  
(b) In the month of `Baisakh`* the rural girls worshipped the tree on the occasion of the festival `Akti`.* |
| 4.      | *Ocimum sanctum* Linn.          | The sacred plant planted in the houses of various Lodhs and other rural inhabitants and is worshipped on the occasion of `Somvati Amavasya`. While worshipping the plant, women move in circle around it for one hundred and eight times for the fulfilment of their desires. |

* = Hindi months of the years.