Competitive fitness of *Centella asiatica* populations raised from stem cuttings and seedlings

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Abstract. *Centella asiatica* (Linn.) Urb., a clonal perennial herb, grows abundantly on a wide range of habitats in Meghalaya and reproduces both through vegetative and sexual means. The paper presents the competitive interaction between the populations of *Centella asiatica* raised from stem cuttings and seedlings, designated as 'Cc' and 'Cs' respectively. The two categories of plants showed significant differences in growth performance. The numbers of stolons and seeds produced by 'Cc' were greater than by 'Cs' in both monoculture and mixtures. The total leaf area and dry matter yield of 'Cc' were greater in monoculture than in mixtures, while the reverse was true with 'Cs'. A comparison of the two categories of plants in monoculture and mixtures reveals that with increased proportion (75%) of Cc in mixture, the yield of Cc increased while the yield of Cs decreased in mixed populations having 75% Cc, thus depicting the competitive superiority of Cc over Cs. The relative yield ratio of Cc to Cs which was greater than unity also confirms that population of *Centella asiatica* raised from the stem cuttings is more competitive than that developing from the seedlings.

Keywords. Competitive fitness; *Centella asiatica*; perennial herb; monoculture.

1. Introduction

Many perennial herbs rely exclusively on clonal multiplication once they have colonized a site and the seedlings if present, rarely survive to adulthood (Sarukhan and Harper 1973; Turkington *et al* 1979; Schmid 1984; Hartnett and Bazzaz 1985). In these plants the genetic changes within a population are largely due to the changes in the abundance and distribution of genets which get established during the initial colonization phase (Schmid 1985). The con-specific populations have been reported to differ considerably in their competitiveness (Snaydon 1971; Ford 1981; Bazzaz *et al* 1982; Heywood and Levin 1984; Clay and Levin 1986; Lee *et al* 1986). Studies on competition between the populations of *Agropyron repens* and *A. canicum* raised from seeds and from tillers (Tripathi and Harper 1973) and between populations of *Imperata cylindrica* raised from seeds and rhizomes (Kushwaha *et al* 1983) reveal that competitive success of plants also depends on the propagules from which they are produced. Such a study may add to our understanding of natural co-existence of genets and ramets and their ultimate contribution to the population maintenance of those species which reproduce both sexually as well as asexually.

*Centella asiatica* (Linn.) Urb. (Apiaceae), a clonal herbaceous perennial is among the most important medicinal plants and in Meghalaya it is used for curing stomachache, dysentery and as blood purifier (Wankhar and Tripathi 1987). The plant is widely spread in Meghalaya under a variety of ecological conditions. It reproduces both through vegetative and sexual means, although the latter mode of
reproduction is negligible. Local patch expansion occurs primarily as a result of clonal growth. In nature the seedling survival is very low (Wankhar 1987). In field conditions, however, populations originating from the seedlings and from the vegetative propagules do come in contact with each other and compete for the available resources. The success of genets depends in large measure, upon the 'stress' created by its own asexually produced allies. An analysis of relative growth of the populations raised from seeds and from stem cuttings in pure and mixed stands may prove rewarding in understanding the population biology and life cycle strategies of such perennial species.

2. Materials and methods

The experiment was performed in a polythene-covered net house. The stem cuttings of uniform length (3-5-4-0 cm, bearing a node) and weight (20-30 mg) and seedlings having 2-3 leaves (10-15 mg dry weight) were collected from the natural population. Keeping the overall density constant (4 plants/pot), the stem cuttings and seedlings were grown in the pots (21 cm diameter, 19 cm depth with a basal drainage hole) filled with garden soil in the ratios of 100:0, 75:25, 50:50, 25:75 and 0:100, so as to give a 'replacement series' (De Wit 1960). The experiment consisted of 5 types of stands x 3 harvests x 5 replicates; thus involving in all 75 pots. The pure and mixed populations of individuals raised from the stem cuttings and seedlings were maintained in the pots with the following density combinations:

(i) Pure population raised from the stem cutting (4 plants/pot).
(ii) Three plants from the stem cutting + 1 plant from the seedling.
(iii) Two plants from the stem cutting + 2 plants from the seedling.
(iv) One plant from the stem cutting + 3 plants from the seedling.
(v) Pure population raised from the seedlings (4 plants/pot).

The planting densities of the stem cuttings and seedlings were 3 times that of the population density of each type of individuals desired to be maintained in the experimental pots. After the cuttings sprouted and the seedlings established, the population was thinned down to the desired density of 4 plants per pot for both pure and mixed stands.

The experiment was started on September 4, 1985 and terminated on July 10, 1986. The 3 harvest were taken at 3 months interval after planting. At each harvest, stolon production, leaf area and dry matter yield were determined. Relative yield (RY), relative yield ratio (RYR) and relative yield total (RYT) (De Wit and Van den Bergh 1965) were computed from the yield data. For the sake of convenience, plants raised from the stem cuttings and seedlings have been designated as 'C_c' and 'C_s' respectively. The data were statistically analysed using ANOVA. The SE of means are given wherever necessary.

3. Results

The two categories of plants showed significant differences in growth performance. After 3 months growth, no stolon was produced either by 'C_c' or 'C_s'; however, after 6 months growth a few stolons were produced. The production of stolons by 'C_c'
and 'Cs' was almost similar when they were grown in pure or mixtures. In general the number of stolons produced by 'Cs' was greater than by 'Ce' (table 1).

The total leaf area and the total yield per pot in mixture were intermediate between the pure stands of both Ce and Cs (figures 1, 2). Seed output of plants

Table 1. Number of stolons and seeds produced per plant in pure and mixed populations raised from cuttings and seedlings of C. asiatica at the final harvest (SEs given along with means).

<table>
<thead>
<tr>
<th>Nature of stands</th>
<th>Stolons</th>
<th>Seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. asiatica</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pure stand (100%)</td>
<td>6.6 ± 0.14</td>
<td>6.19 ± 0.54</td>
</tr>
<tr>
<td>Mixed stands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ce (75%) grown with Cs (25%)</td>
<td>6.7 ± 0.28</td>
<td>6.23 ± 0.7</td>
</tr>
<tr>
<td>Ce (50%) grown with Cs (50%)</td>
<td>6.4 ± 0.19</td>
<td>6.14 ± 0.3</td>
</tr>
<tr>
<td>Ce (25%) grown with Cs (75%)</td>
<td>7.0 ± 1.9</td>
<td>6.72 ± 0.5</td>
</tr>
<tr>
<td>C. asiatica</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pure stand (100%)</td>
<td>4.4 ± 0.38</td>
<td>2.64 ± 0.9</td>
</tr>
<tr>
<td>Mixed stands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cs (75%) grown with Ce (25%)</td>
<td>4.8 ± 0.28</td>
<td>2.97 ± 0.49</td>
</tr>
<tr>
<td>Cs (50%) grown with Ce (50%)</td>
<td>4.5 ± 0.34</td>
<td>2.79 ± 1.65</td>
</tr>
<tr>
<td>Cs (25%) grown with Ce (75%)</td>
<td>4.2 ± 0.47</td>
<td>2.52 ± 1.42</td>
</tr>
</tbody>
</table>

Figures 1-3. 1. Total leaf area/pot (cm²) in pure and mixed populations of C. asiatica raised from the stem cuttings and seedlings after 9 months growth. Leaf area in pure population raised from the (•) stem cuttings (Ce), (○) seedlings (Cs) and (△) mixed populations. 2. Dry matter yield in pure and mixed populations of C. asiatica raised from the stem cuttings and seedlings after 9 months growth. Yield in pure population raised from the (•) stem cuttings, (○) seedlings and (△) mixture. 3. Relative yield ratio of the population raised from stem cuttings (Ce) to that from seedlings (Cs) after 9 months growth. (○), 75% Ce + 25% Cs; (△), 50% Ce + 50% Cs; (•), 25% Ce + 75% Cs. Vertical lines attached to symbols show SD.
developing from the cuttings was more compared with that of plants raised from the seedlings (table 1).

Relative yield of 'Ce' was significantly \((P<0.05)\) greater than that of 'Cs' (table 2). The RYR values were always greater than one (figure 3), which indicates that 'Ce' is more competitive than 'Cs'. The RYT worked out to be more than one at all harvests (table 3).

4. Discussion

The observed differences between the growth of plants raised from the stem cuttings and seedlings could be related to differences in initial weight of the propagules as reported by Tripathi and Harper (1973) and Kushwaha et al (1983) in other perennial plants. The large differences in survival and growth between seedlings and transplants of *Trifolium repens* observed by Turkington et al (1979) were also attributed to the initial differences in plant size between seedlings and ramets. Abrahamson (1980) argued that where both vegetative and sexual reproduction occur simultaneously, the vegetative offspring will develop immediately and quickly.

### Table 2. Relative yield of *C. asiatica* raised from stem cuttings and seedlings at the 3 harvests.

<table>
<thead>
<tr>
<th>Nature of stand</th>
<th>H₁</th>
<th>H₂</th>
<th>H₃</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. asiatica</em> raised from cuttings (Ce)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ce (75%) grown with Cs (25%)</td>
<td>0.97</td>
<td>1.06</td>
<td>1.07</td>
</tr>
<tr>
<td>Ce (50%) grown with Cs (50%)</td>
<td>0.98</td>
<td>1.04</td>
<td>1.14</td>
</tr>
<tr>
<td>Ce (25%) grown with Cs (75%)</td>
<td>0.97</td>
<td>0.89</td>
<td>1.13</td>
</tr>
<tr>
<td><em>C. asiatica</em> raised from seedlings (Cs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cs (75%) grown with Ce (25%)</td>
<td>0.96</td>
<td>1.12</td>
<td>1.06</td>
</tr>
<tr>
<td>Cs (50%) grown with Ce (50%)</td>
<td>0.92</td>
<td>0.89</td>
<td>0.95</td>
</tr>
<tr>
<td>Cs (25%) grown with Ce (75%)</td>
<td>0.90</td>
<td>0.76</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Sources of variation Probability:
- Nature of stand: \(<0.01\)
- Harvest: \(<0.01\)
- Interaction: \(<0.05\)

### Table 3. Relative yield total of *C. asiatica* in different mixed populations at the 3 harvests.

<table>
<thead>
<tr>
<th>Nature of stand</th>
<th>H₁</th>
<th>H₂</th>
<th>H₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ce (75%) grown with Cs (25%)</td>
<td>1.87</td>
<td>1.82</td>
<td>1.93</td>
</tr>
<tr>
<td>Ce (50%) grown with Cs (50%)</td>
<td>1.90</td>
<td>1.93</td>
<td>2.03</td>
</tr>
<tr>
<td>Ce (25%) grown with Cs (75%)</td>
<td>1.93</td>
<td>2.01</td>
<td>2.19</td>
</tr>
</tbody>
</table>

Sources of variation Probability:
- Nature of stand: \(<0.05\)
- Harvest: \(<0.05\)
Competitive fitness of C. asiatica populations

become an adult due to larger food supply in the initial stage of growth. Zangerl and Bazzaz (1983) reported that larger food reserves in the rhizomes of Polygonum compared to its seeds permit the plants of rhizomatous origin to persist in resource-limited environments where plants derived from seeds do not succeed.

There were clear growth advantages gained by the plants raised from stem cuttings at the initial stages but at the later stages the differences had narrowed down so much so that the growth and production of stolons in plants developing from the seedlings and stem cuttings were more or less equal. Keeping in view the low density populations raised in the pots, it could be argued that if ample space is available the seedlings would not suffer extreme growth suppression and may successfully grow into adult plants in nature. As reported by various workers (e.g. Sagar and Harper 1960; Cavers and Harper 1967; Putwain and Harper 1970; Rai and Tripathi 1985), many other species also show little establishment and survival in closed vegetation.

The greater RY and RYR values for Ce compared with Cs depict that the population raised from the stem cuttings is more competitive than that from the seedlings. This agrees with the findings of Tripathi and Harper (1973) and Kushwaha et al (1983). The RYT values (RYT > 1) obtained in the present study suggest facilitation as reported by Clay and Levin (1986) and indicates that the two populations can co-exist provided that there was no crowding. The density per pot was kept quite low in the present study keeping in view that the plant produces stolons which have potentiality to root at each node. This ensured that the pots do not quickly get depleted of resources. The replacement series competition experiments suffer from several limitations as discussed by Taylor and Aarssen (1989) but they definitely provide a sensitive technique by which to compare the competitive behaviour of the species in pure and mixed populations. Taylor and Aarssen (1989) maintain that competitive abilities of the species are density-dependent making it difficult to choose an appropriate density to conduct an experiment. This sensitivity to density, as argued by Firbank and Watkinson (1985) represents a weakness of the replacement-series design in not providing a consistent measure of competitive abilities across a range of densities. In a plant like C. asiatica where density increased with the passage of time, the remarkable consistency with which RY values of populations raised from the stem cuttings and seedlings differed at the 3 harvests (table 2) suggests that the problem of choosing an appropriate density for conducting replacement-series experiment does not pose serious difficulty except that care should be taken to choose a density which provides for future population expansion through vegetative means during experimental duration.

Sexual reproduction in C. asiatica is rendered to be of little ecological significance due to the low production of seeds (table 1) and small soil seed bank (2208/m²) and considerable loss of seed viability (10%) on burial in natural conditions (Wankhar 1987). The small number of seedlings of C. asiatica that appeared in nature may be the result of not only a small seed bank, but of the unmeasured effects of competition from the established plants of C. asiatica and other species which grew in their close proximity. There is close parallel between this plant and Agrostis stolonifera which also has a small seed bank in soil and produces seedlings that are less competitive (Howe and Chancellor 1984). Grime (1979) suggested that the ability of A. stolonifera to dominate the older swards is largely due to its ability to
spread vegetatively and the same holds true for C. asiatica. As pointed out by Alpert and Mooney (1980) and Hartnett and Bazzaz (1983), the risks involved in changing from heterotrophic nutrition to autotrophic life make this stage hazardous, while the daughter rosettes which develop with a continuous supply of resources from the parent plants are able to tolerate the dense situations. The competitive superiority of the population raised from the stem cuttings over that from the seedlings and predominant role of vegetative means of reproduction as reflected by the production of daughter rosettes in large numbers (Wankhar 1987), seem to constitute a viable ecological strategy of this plant enabling it to thrive successfully even in competitive sward situations.

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