CHAPTER 4

EFFECT OF SEASON ON COMPETITIVE BEHAVIOUR OF TRIFOLIUM REPENS AND PASPALUM DILATATUM GROWN IN PURE AND MIXED STANDS
INTRODUCTION

Two or more species simultaneously requiring similar resources may undergo an intense competition which may lead to the ousting of one species by the other. But, by virtue of differences in phenology, growth form or nutritional needs, the species may evade such a direct competition or struggle for existence and 'interniche' in such a way that they persist and co-exist together in nature. The co-existence of the two species of *Trifolium, T. fragiferum* and *T. repens*, is a very interesting case studied by Harper and Clatworthy (1963). Both the species strongly compete for light but they manage to co-exist in nature owing to the difference in their morphological characteristics and asynchronous growth period. Turkington and Harper (1979a), have found that *Trifolium repens* and *Lolium perenne* are intimately associated and have a close cohabitation which has been argued by them to be possible due to the looser tussock of *L. perenne* and the marked asynchrony of growth cycle of these two species. Scarisbrick and Ivines (1970) showed that competitive interactions between pasture plants are influenced by seasonal weather conditions. They observed that *Lolium perenne*, which commences growth in early spring (Blackman, 1933) is more successful in competition. However, during July and August a depression in growth of *L. perenne* occurs (Anslow, 1965) coinciding with the periods when conditions are optimal for the growth of *T. repens* (Blackman, 1933). Lieth (1960) showed that *T. repens* and *L. perenne* form a mobile mosaic in
which low clover density areas are invaded by grass and vice-versa. Besides asynchronous growth of the species in grasslands contributing to their co-existence, the biotic disturbances like grazing and cutting are also vital factors influencing the co-existence (Pradhan and Tripathi, 1980) under field conditions. The legume shows active growth during February-March to July-August showing peak growth in April while the active growth of the grass occurs during April to September showing peak growth during May-June. Thus the two species may be able to avoid intense competition for the resources due to the difference in their growth periods. However, the two species come in direct contact with each other in some part of their growth periods. Thus, the effect of season on the competitive success of the two species was studied by raising their pure and mixed populations, under controlled conditions, in three distinct seasons.

MATERIALS AND METHODS

Four days old seedlings of *T. repens* and *P. dilatatum* were transplanted on 12 July 1979 to the plastic pots of 21.0 cm diameter and 19.0 cm depth filled with sandy loam soil mixed with compost manure in the ratio of 5:1. The amount of soil plus manure per pot was ca. 7.0 kg. The pure and mixed populations of the two species were raised in the following manner so as to give de Wit's 'replacement series' (de Wit, 1960), maintaining an overall density of 8 plants per pot:
The experimental design consisted of 3 proportions x 3 replicates x 3 harvest times. The three harvests H₁, H₂, and H₃ were respectively taken in time sequence at 4, 8 and 12 months after planting.

Besides the above experiment which continued for one year, two short-term experiments each of 4 months duration were also set up. The first short term experiment commenced from 12 November 1979 and the second from 12 March 1980. Various growth characters of the two species were measured after 4 months i.e. at the time of termination of the short term experiments. The harvest time of the first and second short-term experiments coincided with H₂ and H₃ experiments of one year duration.

The short-term experiments were also set up in accordance with 'de Wit's replacement series' with the same proportions and density, as used in the long-term experiment. The short-term experiments consisted of 3 proportions x 3 replicates x 1 harvest.

At each harvest in both the long and short-term experiments, the number of stolons or rhizomes, number of leaves, total leaf area, dry matter yield, allocation of dry matter to aboveground plant parts, and fertile shoot production were
estimated. The dry matter yield was estimated by drying the plant material in an oven at 80°C for 2 days.

The experiments were conducted in an unheated glass house. The minimum temperature in the glass house was recorded to be 6.2°C in January 1980 and maximum (29.5°C) in April 1980. The pots were randomized inside the glass house using the table of random numbers (Fisher and Yates, 1963). An equal amount (500 ml) of water was added in each pot at 3 days interval. A dilute solution of 'cythion' (0.2%) was sprayed regularly on the plants to avoid attack by slugs and larvae.

EXPERIMENTAL RESULTS

Number of stolons and tillers (Table 4.1);

*T. repens* produced greater number of stolons in pure than in mixed stands in long-term as well as short-term experiments. Although there was a progressive increase in stolon production in pure and mixed stands with time, the difference between the pure and mixed stands widened with the passage of time. Number of stolons produced was the same in the short-term experiments set up in November and March. However, at the time of first harvest of the long-term experiment which may be treated as equivalent to another short-term experiment commencing from July the number of stolons produced was comparatively very high. *P. dilatatum*, on the other hand, produced more tillers in mixed than in pure stand in long-term experiment and
Table 4.1: Number of stolons per plant of *T. repens* and tillers per plant of *P. dilatatum* grown in pure and mixed stands after 4 \((H_1)\), 8 \((H_2)\) and 12 months \((H_3)\) from planting in long-term and after 4 months growth in short-term experiments.

<table>
<thead>
<tr>
<th>Nature of stand</th>
<th>Long-term experiment</th>
<th>Short-term experiment no.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(H_1)</td>
<td>(H_2)</td>
</tr>
<tr>
<td><em>T. repens</em> (Pure)</td>
<td>17.65</td>
<td>21.33</td>
</tr>
<tr>
<td><em>T. repens</em> (Mixed)</td>
<td>12.00</td>
<td>19.45</td>
</tr>
<tr>
<td><em>P. dilatatum</em> (Mixed)</td>
<td>6.53</td>
<td>12.67</td>
</tr>
<tr>
<td><em>P. dilatatum</em> (Pure)</td>
<td>5.21</td>
<td>11.67</td>
</tr>
<tr>
<td>F:Variance ratio</td>
<td>36.47**</td>
<td>106.28**</td>
</tr>
</tbody>
</table>

** indicate significant differences at \(P = 0.01\)

* indicates significant differences at \(P = 0.05\)

NS: Not significant
short-term experiment set up in March. However, in the short-term experiment commencing from November, the tiller production by the grass in mixture was slightly lower than in the pure stand (Table 4.1).

**Leaf area** (Table 4.2):

Leaf area per plant of *T. repens* was also lower in mixed stand than in pure in the long-term experiment while in the short-term experiment leaf area was greater in pure stand. *P. dilatatum*, on the other hand, produced more leaf area in mixture than in monoculture except in the experiment set up in November where there was not much difference in leaf area produced in pure and mixed stands. Leaf area of both the species was substantially low when grown during winter while in the short-term experiment commencing from March and in the long-term experiment which was started in July the leaf area was quite high. In long-term experiment, *P. dilatatum* generally showed a progressive increase in leaf area with time, while in case of *T. repens* there was a decline in leaf area after 8 months growth. The magnitude of reduction in leaf area of the legume was much greater in mixture than in pure stand of the long-term experiment. In *T. repens*, the maximum leaf area was observed at H$_2$ of the long-term experiment in both pure and mixed stands. There was a reduction in leaf area of the grass from H$_1$ to H$_2$, but the value increased considerably at H$_3$ (Table 4.2).
Table 4.2: Total leaf area (sq. cm) per plant of *T. repens* and *P. dilatatum* grown in pure and mixed stands after 4 ($H_1$), 8 ($H_2$) and 12 months ($H_3$) from planting in long-term and after 4 months growth in short-term experiments.

<table>
<thead>
<tr>
<th>Nature of stand</th>
<th>Long-term experiment</th>
<th>Short-term experiment no.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$H_1$</td>
<td>$H_2$</td>
</tr>
<tr>
<td><em>T. repens</em> (Pure)</td>
<td>424.27</td>
<td>972.78</td>
</tr>
<tr>
<td><em>T. repens</em> (Mixed)</td>
<td>297.57</td>
<td>949.85</td>
</tr>
<tr>
<td><em>P. dilatatum</em> (Mixed)</td>
<td>531.89</td>
<td>401.91</td>
</tr>
<tr>
<td><em>P. dilatatum</em> (Pure)</td>
<td>302.58</td>
<td>289.98</td>
</tr>
<tr>
<td>F:variance ratio</td>
<td>2.54NS</td>
<td>182.21**</td>
</tr>
</tbody>
</table>

** indicate significant differences at $P = 0.01$

* indicates significant differences at $P = 0.05$

NS: Not significant.
**Dry matter yield (Table 4.3):**

Dry matter yield of *T. repens* was greater in pure than in mixed stands but a reverse trend was exhibited by the grass. The latter showed a progressive increase in dry weight per plant in time sequence in the long-term experiment. *T. repens* also showed a similar behaviour in pure but in mixture the increase was conspicuous from H₁ to H₂ but at H₃, there was slight decrease in yield. The dry matter production of the grass was much greater in the short-term experiment set up in March and also in the long-term experiment where the first harvest was taken after 4 months duration.

*P. dilatatum* accumulated more biomass than *T. repens* both in pure and mixed stands. The difference in the mixture yield and the pure stand yield of *P. dilatatum* increased with the passage of time (Fig. 4.1a and b).

**Fertile shoot (%):**

*T. repens* showed some flowering in the short-term experiment harvested in July in pure stand but did not show any in the mixed stand showing thereby that the grass is more favoured by the climatic conditions prevailing during this period and its luxuriant growth suppresses the flowering of *T. repens* in mixture. This is also evident from the long term-experiment where the flowering of *T. repens* was much lesser in mixed than in pure stand. In the long-term experiment, *T. repens* showed flowering
Table 4.3: Dry weight (g) per plant of *T. repens* and *P. dilatatum* grown in pure and mixed stands, after 4 (H₁), 8 (H₂) and 12 months (H₃) from planting in long-term and after 4 months growth in short-term experiments.

<table>
<thead>
<tr>
<th>Nature of stand</th>
<th>Long-term experiment</th>
<th>Short-term experiment no.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H₁</td>
<td>H₂</td>
</tr>
<tr>
<td><em>T. repens</em> (Pure)</td>
<td>2.34</td>
<td>6.86</td>
</tr>
<tr>
<td><em>T. repens</em> (Mixed)</td>
<td>1.94</td>
<td>3.57</td>
</tr>
<tr>
<td><em>P. dilatatum</em> (Mixed)</td>
<td>9.57</td>
<td>15.93</td>
</tr>
<tr>
<td><em>P. dilatatum</em> (Pure)</td>
<td>5.03</td>
<td>10.98</td>
</tr>
<tr>
<td>F:variance ratio</td>
<td>41.85*</td>
<td>52.62*</td>
</tr>
</tbody>
</table>

** indicate significant differences at P = 0.01
* indicates significant differences at P = 0.05
NS Not significant.
Fig. 4.1(a): Replacement diagram based on total biomass/pot of *T. repens* (---●--) and *E. dilatatum* (---○--) grown in pure and mixed stands after 4 (H₁), 8 (H₂) and 12 months (H₃) from planting. The combined yield per pot (---x---) is also given.
Fig. 4.1(a)

Long term experiments

H3

H2

H1

Ratio grown

Biomass (	ext{g} / 50 \text{g})
Fig. 4.1(b): Replacement diagram based on total biomass/pot of *T. repens* (---) and *P. dilatatum* (---) grown in pure and mixed stands after 4 months from planting. The combined yield per pot (---x---) is also given.
Fig. 4.1(b)  Short-term experiments
after 8 months growth at $H_2$ i.e. in March. Here again the percentage of fertile shoots was considerably higher in pure stand than in mixture. *P. dilatatum*, on the other hand, suffers more from intra-specific competition and so with decrease in number of the grass plants as is the case in mixed stands, percentage of fertile shoots increases. Percentage fertile shoots in the grass was quite high at $H_1$, but at $H_2$ the grass did not show any flowering indicating that environmental conditions between $H_1$ and $H_2$ are not favourable for its reproductive growth. However, with the onset of warm weather conditions the grass again showed flowering at $H_3$ (Table 4.4).

*T. repens* generally showed higher aboveground yield in pure stand than in mixture, while *P. dilatatum* behaved just the reverse in both long-term and short-term experiments. However, both the species showed very poor growth during winter as is apparent from the results of short-term experiment set up in November, and so, the differences due to species or due to nature of stands was not discernible. This, however, indicates that the suppression in growth of *T. repens* which is generally caused by the luxuriant growth of the grass no longer occurs during winter months characterized by unfavourable weather conditions.

The data on aboveground yield per pot of the two species also confirm this point (Fig. 4.2a and b).
Fig. 4.2(a): Replacement diagram based on total aboveground biomass/pot of *T. repens* (---•---) and *P. dilatatum* (---o---) grown in pure and mixed stands after 4 (H₁), 8 (H₂) and 12 months (H₃) from planting. The combined aboveground yield per pot (---x---) is also given.
Fig. 4.2(b): Replacement diagram based on total aboveground biomass/pot of *T. repens* (---●---) and *P. dilatatum* (---○---) grown in pure and mixed stands after 4 months from planting. The combined yield per pot (---×---) is also given.
Fig. 4.2(b)

Short term experiments

Above-ground biomass (g) p0.1

Ratio grown
DISCUSSION

The growth of *P. dilatatum* and *T. repens* in pure and mixed stands shows that the grass is a better competitor than the legume. However, it seems to suffer more from intra-specific competition, while in inter-specific competition the legume suffers miserably, in spite of the asynchronous growth pattern of the two species. However, during November to March, the grass failed to suppress the growth of *T. repens* as the grass itself showed quite poor growth due to unfavourable conditions prevailing during the period. Compared with the yield of the two species in other experiments the reduction in growth of *P. dilatatum* during winters was reduced to a very great extent while the magnitude of reduction was not that high in *T. repens*, which is a temperate species and so it may probably withstand low temperature conditions better.

In the experiments where the two species were allowed to grow during relatively warm period, the grass invariably gets an upper hand which is shown by its better growth in the mixed population, and the legume growth is suppressed on account of severe competition offered by fast growing *P. dilatatum*. The time taken between planting to flowering is longer in *T. repens* than in the grass (Table 4.4). Thus the grass completes its flowering before winter season which represents a period of inactive growth for the grass. The plants of *T. repens* grown in July (long-term experiment), however, showed flowering even
Table 4.4: Percentage fertile shoots of *T. repens* and *P. dilatatum* grown in pure and mixed stands after 4 (H1), 8 (H2) and 12 months (H3) from planting in long-term experiment and after 4 months period from planting in short-term experiments.

<table>
<thead>
<tr>
<th>Nature of stand</th>
<th>Long-term experiment</th>
<th>Short-term experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H1</td>
<td>H2</td>
</tr>
<tr>
<td><em>T. repens</em> (Pure)</td>
<td>0</td>
<td>9.56</td>
</tr>
<tr>
<td><em>T. repens</em> (Mixed)</td>
<td>0</td>
<td>2.31</td>
</tr>
<tr>
<td><em>P. dilatatum</em> (Mixed)</td>
<td>35.68</td>
<td>0</td>
</tr>
<tr>
<td><em>P. dilatatum</em> (Pure)</td>
<td>38.39</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4.5: Relative yield of *T. repens* and *P. dilatatum* grown in pure and mixed stands after 4 (H1), 8 (H2) and 12 months (H3) from planting in long-term experiment and after 4 months period from planting in short-term experiments. Quotient of relative yield of *T. repens* to *P. dilatatum* is also given.

<table>
<thead>
<tr>
<th>Relative yield</th>
<th>Long-term experiment</th>
<th>Short-term experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H1</td>
<td>H2</td>
</tr>
<tr>
<td><em>T. repens</em></td>
<td>0.42</td>
<td>0.26</td>
</tr>
<tr>
<td><em>P. dilatatum</em></td>
<td>0.95</td>
<td>0.73</td>
</tr>
<tr>
<td>Quotient of relative yield of <em>T. repens</em> to <em>P. dilatatum</em></td>
<td>0.44</td>
<td>0.36</td>
</tr>
</tbody>
</table>
during winter which again indicates that the legume can manage to grow relatively better than the grass during winter months, although in short-term experiment set up immediately before the onset of winters the legume also did not show any flowering until March. With the rise in temperature after winter months, the grass once again shows active growth and starts flowering at $H_3$ of the long-term experiment. Further, the increase in dry matter yield from $H_2$ to $H_3$ both in pure and mixed populations was much greater in the grass in comparison with the legume. It may, therefore, be generalized that *P. dilatatum* grows better than the legume during most of the year except in winter season.

Competitive outcome in favour of the grass is also confirmed by the relative yield values of the two species (Table 4.5). The quotient of relative yield of *T. repens* to *P. dilatatum* which was always <1 suggests that the legume invariably loses to the grass in competitive situations. The only exception to this generalization is the competitive behaviour of the two species grown during winters. Donald (1963) showed that shading caused by tall growing grass species suppresses the growth of legumes. In the present study as well, the growth of the legume in mixed population suffers on account of shade caused by the tall growing *P. dilatatum*.

Kershaw (1959) showed a positive association of *Trifolium repens* with *Lolium perenne* and negative with *Dactylis glomerata*
and Agrostis tenues. Turkington and Harper (1979a) found a close cohabitation of T. repens and L. perenne and they attributed it to looser tussock of the grass. In field conditions, the two species show asynchronous growth pattern, with T. repens starting its active growth phase much earlier than the grass, but once the grass comes onto the scene the legume faces a very tough competition due to rapid growth of the grass.

As indicated by the competitive behaviour, the species probably cannot co-exist for long duration in spite of their asynchronous growth. It is observed that the grasslands at Shillong are dominated by the legume (T. repens) during March to May and by the grass (P. dilatatum) during August to November. An earlier study (Pradhan and Tripathi, 1980) has shown that the growth of P. dilatatum in protected areas free from grazing and other biotic disturbances results into virtual elimination of T. repens. This has been attributed to poor availability of light, on account of luxuriant growth of P. dilatatum to the legume which occupies the lowest stratum in the grassland vegetation. Their co-existence in field conditions, owes to the biotic disturbances like grazing, cutting and trampling which are so common in the local grasslands.