10 Summary

The present study on nodule population dynamics in Trifolium repens conducted at Shillong in north-east India during June 1991 - May 1993, aimed at determining how the nodule population in the two distinct populations of this legume, viz., the marked and unmarked leaf morph populations, were affected under different ecological conditions. The study was carried out in two parts - field study under natural conditions and net house experiments where conditions could be manipulated.

The field study was conducted in a sward having a profuse growth of Trifolium repens. The sward also contains Anemone rivularis Ham., Arundinella spp., Axonopus compressus (Sw.) Beauv., Centella asiatica L., Fimbristylis dichotoma Vahl., Hypocharis radicata L., Pennisetum clandestinum Hochst.ex.Chiov., Plantago major L., moss and other minor constituents. T. repens comprises two distinct leaf morph populations - one with conspicuous 'V' shaped white markings on the leaflets (marked population) and the other with no such markings (unmarked population).

In the sward, two plots of around 0.25 ha each were selected. The first plot received sunlight for the major part of the day whereas the second plot was partially shaded due to an existing row of trees towards the southern periphery of the site. T. repens plants of both leaf morph populations were sampled at monthly intervals and the shape, size and number of root nodules and various other growth parameters were studied. The edaphic variables of the study plots were also studied.

In the net house experiments, white clover plants were raised in plastic pots (15 cm diam., 16 cm depth) filled with acid washed sand or with a mixture of sand and soil, inoculated with previously-isolated rhizobia, and the effects of different controlled conditions on the nodulation pattern studied. The plants were raised in the pots using the uniform pieces of ramets obtained from the field populations.

The field observations revealed that nodule number per plant varied seasonally with the maximum number of nodules borne during the late rainy season, corresponding to peak vegetative growth, and the minimum number developing during the winter. Of the two leaf morph populations, the marked population consistently exhibited greater nodule number per plant. In the marked population, the mean number of nodules per plant was maximum (22.0) during October 1991 and minimum (2.4) during February 1993. Corresponding values for the unmarked population were 16.2 and 1.8 during July 1992 and January 1993, respectively. The nodules were grouped into

five categories based on their size and the number of lobes: category 'a' - unbranched and 0-3 mm in length, category 'b' - those with 2 lobes or unbranched and 3-4.5 mm in length; category 'c' - with 3 lobes and up to 4.5 mm in length; category 'd' - 2 or more lobes and 4.5-6.0 mm in length, and category 'e' - 3 or more lobes and >6 mm in length.

The maximum number of nodules recorded from both the leaf morph populations were of category 'a'. Up to 60.1% of the nodules belonged to this category in the unmarked population from the 'open'. The unmarked population from 'shade', marked population from 'open' and marked population from 'shade' had lower percentage of nodules in category 'a', the respective values being 47.6%, 47.9% and 46.5%. The unmarked population from 'open', which had the highest percentage of its nodules in category 'a', had the lowest percentage (3.0%) of the nodules in category 'e'. Among the various populations sampled, the marked population from the 'shade' had the highest proportion (8.6%) of nodules in category 'e'.

Among the major edaphic variables, soil temperature and soil moisture showed a significant positive correlation with nodule number in both leaf morph populations. Nodule number was also correlated with soil pH. Among important growth parameters, the number of rooting nodes per stolon and photosynthetic area per plant showed a significant positive correlation with nodule number in both leaf morph populations.

The effect of varying levels of soil N, soil pH, soil moisture

and defoliation on the nodule population of T. repens were studied by performing several nethouse experiments. To study the effect of varying levels of soil N on the nodule population of white clover, the plants were exposed to 0, 0.1, 0.5, 0.75, 1.5, 3 and 6 mM NO_3 or NH_4 (supplied as KNO_3 and NH_4Cl respectively). With increasing levels of NO_3 or NH_4, the nodule number per plant showed an initial increase and then sharply declined with further increase in N levels showing a total inhibition of nodulation at the highest N level. In both NO_3 and NH_4 treatments, the plants of the marked population developed a greater number of nodules as compared to the unmarked population. Of the two treatments, nodule number per plant was greater in the NH_4 treated plants. The mean nodule weight of plants from both leaf morph populations showed a strong negative correlation with nodule number per plant. This was true for both NO_3-treated as well as NH_4-treated plants. Of the two populations, the marked one also exhibited greater nodule mass per plant. The total N content per plant varied significantly between the different N levels. In both NO_3 and NH_4 treatments, the N content per plant was significantly greater in the marked population than in the unmarked population.

The clover was grown in sand+soil mixtures adjusted to pH 4.5, 5.0, 5.5, 6.0 or 6.5 to study the effect of varying pH levels on the nodule population dynamics. At pH 4.5, plants of both leaf morph populations failed to nodulate, but with increasing pH the nodule number increased sharply up to pH 6.0 beyond which level,

the nodule number dropped considerably. In general, the marked population exhibited significantly greater number of nodules as well as nodule mass per plant compared to the unmarked population. The total N content per plant showed a steady increase with increasing pH in both the leaf morph populations. The total N content per plant was significantly greater in the marked population compared to the unmarked population.

The effect of varying levels of soil moisture on nodulation was determined by growing the two leaf morph populations in sand+ soil mixture at 10%, 20%, 30% and 40% moisture levels on dry weight basis. The nodule number per plant showed a gradual increment with an increase in soil moisture levels up to 20%, beyond which there was a drastic reduction in the nodule population. The marked population consistently exhibited greater nodule number per plant compared to the unmarked population. The total nodule mass per plant also varied significantly amongst moisture levels. Total N per plant increased up to 20% soil moisture level and thereafter decreased with increasing soil moisture levels.

To study the effect of defoliation and NPK levels on the nodule population in T. repens, the plants were exposed to two defoliation and two NPK levels - high and low. The sand+soil mixture represented low NPK level, to which amendments were made to maintain a high NPK level. The plants of both leaf morph populations were thus subjected to one of the following treatment combinations: (i) 'low defoliation-high NPK (LH), (ii) 'high defoliation-high NPK' (HH),

(iii) 'low defoliation-low NPK' (LL), and (iv) 'high defoliation-low NPK' (HL). Besides, respective controls were also maintained for the two leaf morph populations. The nodule number as well as nodule mass per plant varied significantly between treatments and the greatest number of nodules per plant was recorded in LH and the smallest number in HL treatments for both the leaf morph populations. The marked population consistently exhibited greater nodule number and nodule mass per plant compared to the unmarked population. The nodule mass per plant as well as total N per plant were highest in the 'controls' and lowest in the HL treatments in both populations.

Results of the study indicate that nodulation in T. repens is affected by a wide range of ecological conditions, directly or via their effects on the growth of the host legume. Not only is there a seasonality in the growth and functioning of the root nodules as obvious from the field data, but short-term localised changes in the edaphic conditions or external stress factors also affect their development, longevity and functioning. Of the two leaf morph populations, plants of the marked population consistently exhibited greater nodule number and nodule mass per plant under various ecological conditions. This results in plants of this population having a larger quantity of N_2 fixing nodule tissue which makes this population, under identical conditions, more efficient in so far as N_2 fixation is concerned. Thus the marked population of T. repens could be expected to play a more significant role in the

nitrogen economy of grassland ecosystems compared to the unmarked population.