SUMMARY OF SOME RED CLOVER INVESTIGATIONS IN CANTERBURY.

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An attempt was made by the writer at Lincoln College in 1928-29 to find out a few facts about the reaction of red clover relative to its environment and to the possibilities of improving its production. The facts will be presented under the headings of Polymorphy, Reaction to Biotic factors and Selection,

I. POLYMORPHY.

A Observation on plants comprising a sward at once reveal; lack of definite uniformity in type, while closer examination provides evidence of greater diversity than is consistent with that expected in the normal Gaussian curve of variation. This condition prevails on all stands sown with the ordinary commercial strain of red clover procurable in N.Z.

Characteristic first impression features are that the population consists of a preponderance of early flowering broad red, types that are comparatively short lived, this latter feature being gauged by the thinning out of the sward after the second year, By a series of gradations scarcely perceptible the minor part of the population at the other end of the scale consists of later flowering,, smaller-leafed, more permanent types. This state of affairs is to be expected 'in a typically annual climate that prevails in Canterbury, where seed production has caused an unconscious selection of certain more temporary types, Casual observation shows that diversity in individuals is due to polymorphy of the leaf, stem,. flower;, roots and productivity.

B. Measurement. The necessary critical information and proof could only be obtained experimentally.

Plants taken from an old pasture were broken up into tillers and planted in rows, and observations made on total productivity per plant which varied from 231 grs. to 1085 grams, while the mean yield was 559 grams, These differences were greater than could be consistent with soil variation.,

Variation in the periodicity of growth is well illustrated by graphs which show that the majority of plants produce a flush growth in early summer and peter out, while a small proportion carry on much later into the season.

Information on the time of flowering and length of flowering period revealed that some plants flower early, profusely and for a short time, while others flower later, and the flowering period is much longer and less prolific.

Incidence of rust showed that some were -susceptible while others were immune. Young vigorous growth was more immune than mature growth.

Other outstanding characters which differentiate plants and will be discussed later are the number of stems per plant,(which gives the plant a dense or lax rosette) the size and shape of the leaf end the proportion of leaf to stem.

It became necessary to determine whether polymorphy was due to epharmonic response or genetical diversity.

C. Inherent Nature. Two experiments designed to give evidence were instituted:

1. In order to avoid confusion between gradation from one type to another, two distinct, types of plants were selected from a field, broken up into tillers and planted under similar conditions and alternated in a plot, Plants with dense rosettes were contrasted with lax rosette plants. Subsequent treatment was similar for both, but at the end of the trial individual plants were unaltered.

2. It was found on clay soil that root development was peculiar in that a short tap root, big lateral and many adventitious surface roots were found; on sandy soil a very long tap root had developed at the expense of ail others; while on medium loam the normal type of roots was found. Plants of the above types were secured, broken up into tillers, planted and treated simultaneously on prepared -plots of clay, sand, hard soil, cultivated soil, ordinary loam (control), while other plots were topdressed, grown in competition with ryegrass and allowed to grow rank. Throughout the experiment the above ground form of the individuals remained distinct. Comparison of root development two years later showed no visual or measureable difference despite original lack of uniformity. It was apparent that it was impossible to prepare the above exaggerated plot conditions effectively, and also that the original plants were adapted to the soil conditions under which they grew, but as soon as normal conditions prevailed a normal root development resulted.

Thus root, development seems to be an inherent character which is plastic within certain limits under extreme soil conditions, allowing the plant to adapt itself in relation to water supply.

II . RESPONSE TO ECOLOGICAL FACTORS,

A, Direct Factors. Apart from the effects of water at different depths in the soil, on root development and two inconclusive experiments on the effect of soil 'aeration and effect of frost, no information was collected on the above.

B. Biotic Factors. The following. field experiments were designed in order that: a comprehensive analysis of the collected data might yield sufficient facts to unravel. the co-mingled cause and effect relations resulting from the above factor complexes, i.e. reaction to the grazing animal, interference by man and competition which results ultimately in succession.

The following is a brief survey of the experimental evidence:-

1 . Suppression effect of ryegrass. Tillers of red clover plants were planted in adjacent plots,, and comparison by Student's Method made, between those plants growing in competition and those with no competition. The average production of those under competition was 13.6 grams, as compared with 65 grams produced by plants with no competition,, (odds in favour of significance 1000 - 1). Thus ryegrass competition is a potent factor in red clover production.

2. Mortality experiments, In three different fields containing respectively young, 2 - 3 year old, and old pasture, plots 22 x 2 yards were marked off and the red clover population counted five times at intervals over a period of 18 months, The fields were grazed normally throughout* The counts were corrected for delayed germination and establishment due to re-seeding.

Inmyoung pasture 29% of the original plants remained.
" 2-3 year " 39% " " " "
" old " 58% " " " " "

Although there is a big decrease in population apparently as a result of grazing, it is masked in practice by establishment of young plants, The decline in number of plants was definitely influenced to a greater extent by severe grazing than by seasonal adversity.

3. Observation of marked plants. 160 plants of two types (dense and lax rosettes) were marked by pegs and periodical observations made in order to determine which type was most persistent and at what season of year deaths were most frequent. Over a period of 16 months 16% died, 12% of which were lax rosette plants and 4% dense rosette plants, Slightly more deaths occurred in the autumn period than in the winter period,

4, Imitation of severe grazing. As grazing seemed to have such a marked effect on red clover an attempt was made to measure the effect by svserving plants whose crowns mere cut artificially.

Sixty plants were marked in a field and half of them kept as controls, in addition, the field was heavily grazed throughout the winter. A year later practically all the cut plants were dead or partly decayed, while less than 50% of the untreated plants were dead despite the heavy winter grazing. From this it would seem that damage due to grazing is a potent factor in the longevity of red clover..

5. Analysis of plants on a severely-grazed pasture. 100 plants were examined at random and various facts recorded&Some time previously the pasture had been allowed to grow rank and was then severely grazed, thus the crown of the plant is left unprotected and liable to injury, From the information collected a tentative cause and effect sequence was established between exposed plants - severe grazing - injured crown which later divides - crown rot - root rot - and finally death. The number of plants in each group indicates such a sequence.

6. Differential grazing trial. The object of this trial was to determine the reaction of red clover to various forms of management by counting periodically the plants and determining by mortality the relative efficacy of treatment. Six plots of 1/40 ac. each were fenced off in a field sown 6 months previously with 20 lbs. of Italian Rye and 4 lbs. of red clover per acre. Five different treatments or possible forms of management were simulated as nearly as possible, and information was collected on productivity, size and rate of mortality' of clover plants, bare ground, weed invasion and volunteer grass and clover species, Observations were made over a Period of 21 months.

Notes on Treatment and Effect.

A. The selectively or extensively grazed plot was part of a large field. Dominantly ryegrass 98% in first season and dominantly red clover 80% in seoond season with a little weed invasion and seedling ryegrass,

B. This plot was ungrazed and uncut, while the roughage was removed at the end of the season. Dominant ryegrsss greatly suppressed red clover, and when remov'ed there was 90% of bare ground. Dominant red clover'smothered all other growth in second season.

C. On the hayed plot the first cut was all ryegrass. The aftermath was 50% red clover and 50% ryegrass, weeds and bare ground, In the second season red clover occupied 60% and 40% weeds of the area. Red clover plants were larger than on any other plot. Conditions seemed ideal for weed establishment.

D. Under controlled grazing in the first season ryegrass was dominant until summer; red clover becoming prominent then with the wane in production, but the sward did not open up as on other plots, In second season original ryegrass still persisted and red clover became more dominant 80% until later in the season when it completely covered the area preventing weed invasion. Some ryegrass persisted to the end of the trial. Changes in this plot were gradual.

E. Close and continuous grazing had by the first summer killed all the ryegrass leaving 60% bare ground., Red clover plants were small with dense tufted rosettes, Weed invasion was extensive in winter. Red clover plants did not increase in number and occupied 15%, white clover 40%, weeds 15% and bare ground 20% of area at the end of trial,

The behaviour of the red clover plants can be gauged from counts, corrected to 100 plants per plot initially.

	Sep.'28.	March-'29.	Sep.'29.	Dec.'29.	May '30
Selective Grazing	100	266	300	230	208
Hayed	100	258	215	208	200
Rank Growth	100	175	140	140	112
Controlled Grazing	100	188	232	236	208
Close Grazing	100	105	75	72	54

The various treatments were reflected by the behaviour of the plants. In all cases there was an increase over the initial

establishment of clover and the population waned or increased according to the favourableness of management . Delayed germination indicates 'the value of nursing for only 2.4% of seed sown had established at the end of 6 months and 5.1% at the end of 12 months There were no deaths for the first 18 months and the decline in numbers was least rapid under controlled grazing. Continuous grazing and rank growth treatment are the most deleterious, while recuperation after cutting or grazing was most rapid on the hayed plot, then on the controlled grazing plot and lastly on close grazing plot,

Grazing records showed that the controlled grazing plot carried an equivalent of 9.5 sheep per acre while the selectively grazed plot carried 5 sheep per acre for the year. The longevity of ryegrass depends largely on management. The invasion- of weeds was most serious on the close-grazed and hayed plots .

The relative amount of competition between species depends on treatment, Succession on each plot was definitely modified by management.

It is now pertinent to discuss succession in the light of the partly unravelled complex of biotic factors,acting through the direct factors which in turn impugn upon the diverse inherent make up of the population.

A. Competition must ultimately result from the efficiency with which a plant can make use of the material at its disposal.

Interspecific competition evolves from inherent tendencies which primarily create it, consequently it is proportional to the heterdgeniety of the population, Autecological characters of importance are speed of germination, life or above-ground form, rooting capacity, periodicity. of growth andlength of the growing season, since uneven distribution of the characters enables certain plants to use them to advantage,

Intraspecific competition depends on autecological characters of competing plants, consequently among different species-there Will be' more severe competition owing t 0 an exaggerated range of different characters.

B. Grazing is the biggest factor influencing competition since it places the inter-relation of plant characters in a new perspective making adaptability an important factor, The type of grazing depends on management, if severe, considerable lasceration of shoots and crowns, tramping and selective uutting of tender shoots take place,, but ideally it should be merely a pruning effect. Root development is proportional to the above-ground size of the plant so that ideal grazing will depend upon the optimum size to, which plants must attain before they can be utilized to the best advantage. In a trial where red clover was cut at varying growth intervals indications were that less frequent grazing would be more efficient*

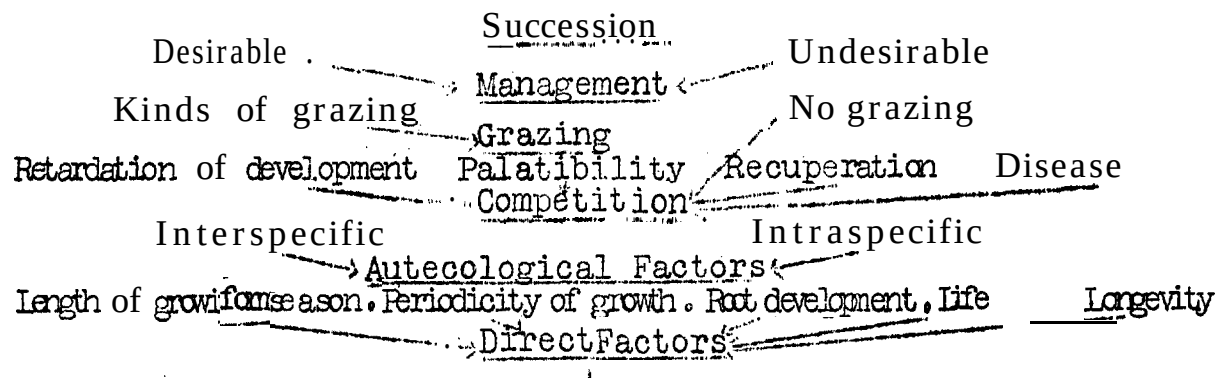
The opening up of the sward by grazing is compensated for by induced tillering, which was a feature of the grazed plots. Life form is important from a grazing standpoint, The ability of a plant to produce tillers indefinitely allows of quick re-cuperation after grazing and protection from grazing, while depression of the crown also affords protection,

Mortality of plants was found to be in proportion to the severity of grazing which occasions injury, allowing rot organisms acting in conjunction with diminished vitality to cause death.

C. Man ement acting through various channels - sowing - nursing - top-dressing - cultivation - summer mowing or haying largely controls succession. Mismanagement in the form of over-stocking, rank growth, overgrazing in the autumn when red clover is practically the only green feed, or when it is present in small proportions in the pasture causes loss of plants allowing of bare ground and weed invasion,

D. Succession. Since succession reflects critically' upon management its value as a criterion is great because, as good management should, it takes cognisance of all the preceding

factors. The variation in appearance and components of different red clover stands proves how their success depends upon the action of the above factors. The inter relation of the chief biotic factors at a glance would seem to be thus:-



III. SELECTION. In order to establish a sound basis in approaching the complex of factors influencing selection, statistical analysis of the prominent morphological and physiological characters of the plant was carried out. In the light of the previous work certain characters seemed to be correlated wi th each other and with productivity. Since the dense rosette or multi-tillered t ype appeared to meet all requirements and its density could be represented by stem counts per plant, this character was compared with various others of economic Importance.

The number of plants used varied between 25 and 100 in each experiment.

The following correlations were found to exist:-

Number of stems	- total rooting capacity	·98 ± ‘001
" " "	- weight of adventitious roots	·99 ± ·002
" " "	- percentage of leaf	~~~~ 88,t,’ 003
" " "	- percentage of leaf (No.2)	·92 ± ·0001
" " "	- persistency	·9 ± ‘01

The above figures illustrate that there is almost perfect correlation exist ing between denseness of rosette, leaf iness, productivity, rooting capacity, and persistency so that the ideal type of plant becomes defined.

Further probf was obtained by testing typical plants in a single plant productivity trial using 20 plan ts of each type. The dif ferences in yield are all significant..

Dense rosette type	Lax rosette type	Cornish Marl type
624 ± 24 grams	390.5 ± 18 grams	442 ± 26 gram

Since it is possible to recognise the ideal type visually, largely by the type of rosette, it is possible to segregate it, from others and work with it, A collection of these plants could be obtained from ordinary commercial seed, but when overseas strains of red clover are examined it is found that, Montgomeryshire red contains a high proportion of this type,

IV. MASS SELECTION. A mass selection from Montgomeryshire red clover suggests itself as the next step in improvement, but will be limited by the breeding behaviour and purity of this type. A parent-offspring correlation of .8 encourages work along this line. Further it was demonstrated that seedlings raised from mass-selected plants under controlled pollination outyielded seedlings raised from open-pollinated mass selected plants by 31% (odds in favour of significance 999-1)

SOME CONCLUSIONS. The observed polymorphy was shown by measurement to be definite and its inherent nature was proved, although due to epharmony to some degree. Under field conditions statistical examination was made of the response of red clover to many biotic factor complexes which were reduced where possible to experiments on single factor effects, in the hope that solution would systematic and sequential. More intensive investigation is indicated. The role of management in the effect of competition, utilization, avoidance of the fatal severe-grazing sequence & control of succession to avoid weed invasion were illustrated. Certain characters of suitable plants were brought into prominence some of which were reactional adaptations & these combined with other information provided a basis for selection. Having defined the most suitable type, correlation of important characters, viz density of rosette, leafiness, resistance to grazing, rooting capacity, productivity and persistence provided stronger evidence in favour of selection of a type found in Montgomeryshire red clover, the breeding behaviour of which is promising under controlled mass selection.