# Assessment of Grazing Procedures in the Evaluation of Plant Breeding Material

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# ASSESSMENT OF GRAZING PROCEDURES IN THE EVALUATION OF PLANT BREEDING MATERIAL

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## ABSTRACT

Four stocking densities (2, 3, 5 and 9 sheep/18 $m^2$ for one hour) and two times of grazing (morning or evening) were imposed on a spaced plant nursery of nine red clover (*Trifolium pratense* L.) populations of varying growth habit, in order to optimize measurement of sheep grazing preference. Plant height, spread and leafiness were measured before and after each of three grazings. Sheep preference was viewed multivariately, using combined measurements of these plant characteristics. MANOVA revealed that the effect of stocking density was significant (P-0.05), but that of time of grazing was not. The plant, population and overall heritabilities were non-significant ($P>0.05$) for before-and-after grazing differences for all characteristics, and also for leafiness after grazing. Overall heritabilities for after-grazing spread and height were significant at 0.37 and 0.30, respectively. Sampling reliability at the 5 sheep/18 $m^2$ stocking density was 94%, which was superior to the lower grazing intensities; this stocking density was considered to be the best for subsequent evaluation work. Either morning or evening grazings could be used.

## KEYWORDS

Red clover, plant breeding, diet selection, germplasm evaluation, sheep preference

## INTRODUCTION

Cutting is often used to simulate grazing in forage crop evaluations, but many researchers question the validity of this approach because of the absence of selective defoliation, treading, and excretal return (Hodgson, 1981; Evans *et al.*, 1992; Grant and Marriott, 1994).

Red clover (*Trifolium pratense* L.) is an important temperate forage legume. One selection goal of breeders is to improve grazing preference based upon discrimination by grazers among plants or plant parts. This experiment explored a grazing management system which maximized discrimination for grazing preference amongst plants and populations. Heritability, plant diversity and sampling reliability were major decision criteria.

## MATERIALS AND METHODS

The experiment was conducted at Massey University, (40° 23'S, 175° 37'E), on fertile floodplain soils. Factor A consisted of nine red clover (*Trifolium pratense* L.) (2n=14) populations with different origins. Three were prostrate, three semi-erect and three erect. Factor B consisted of four stocking densities (2, 3, 5 and 9 sheep/18 $m^2$), and factor C was time of grazing (morning or evening). This (4 (stocking densities) x 2 (times of grazing)) Factorial was randomized into 2 blocks, giving 16 grazing units (GU). Each GU consisted of a grid of 9x5 spaced plants (0.75 m in both directions) centrally located in an 8x5 m area enclosed by electric fence, which included a 1 m fallow border to separate grazing from the fence. Forty-five seedlings (factor A) were transplanted from glasshouse to field in spring and were assigned completely at random to each GU grid. Three repeated measures (grazings) (Gill, 1986) (factor D) defined a second split.

When the semi-erect populations averaged 25 cm height, the whole experiment was grazed. Spread (cm), height (cm), and leafiness (percentage canopy, meristic score) were recorded before and after each grazing. Sheep were then re-introduced to defoliate all treatments to a uniform hard level.

Sampling intensity was determined using the differences between measurements before and after grazing. If any plant had a smaller spread, height or leafiness after grazing than before grazing, it was considered grazed.

The three plant characteristics were analyzed jointly in order to examine grazing "profiles" (MANOVA). Subsequent ANOVAs provided variance components for heritability estimates, and for indication of variability amongst and within populations.

Plant, population and overall heritabilities were considered using the usual restricted definition of phenotypic variance (Allard, 1960), which excludes several environmental variances. Standard errors of heritabilities were calculated following Osborne and Paterson (1952) methodology. Two other experiments examined the same populations, but used clones to partition plant variance into genetic (g) and environmental components. Their mean g-ratios were used to partition plant variance in this experiment, the values used for spread, height and leafiness (after-grazing) being 0.36, 0.25 and 0.0 respectively. Plant genetic variances (g) for the before-and-after differences were 0.0 for all characters.

## RESULTS AND DISCUSSION

Average grazing height for the group of semi-erect populations was 24.3 cm., close to the target of 25 cm. None of the characters measured before each grazing differed significantly ($P>0.05$) among the four stocking densities or the two times of grazing. This was expected for the first grazing period (which preceded treatment imposition). The result for later grazings showed that the "post-treatment" grazing was effective in maintaining uniform starting conditions for subsequent grazings. Characters measured after grazing and before-and-after grazing differences were significantly (P-0.05) different for stocking density, but only post-grazing spread and differences in spread and leafiness differed significantly between times of grazing (P-0.05). MANOVAs confirmed that the effect of stocking density was highly significant (P-0.05), but that time of grazing was not significant.

The situation after the four stocking densities were imposed is illustrated in Figure 1. There was a significant (P-0.05) reduction in all characters when the intensity of defoliation increased, showing that the treatments were causing their expected effect. Leafiness was the character most responsive to stocking density.

Plant, population and overall heritabilities of spread, height and leafiness before-and-after grazing were estimated (Table 1). Heritabilities of the before-and-after differences of all characters were zero, as well as that for leafiness after grazing. Thus, all of these variables were of little use for plant selection. Spread and height after grazing were the most useful selection characters.

The variances before and after grazing at the plant and population level for each characteristic were compared at the four stocking densities, since post-grazing variation provides the basis for selecting for animal preference. No contrasts were statistically significant (P>0.05), so no conclusion could be drawn on the basis of usable variability.

Another criterion of usefulness is that all plants be sampled, but not over-grazed. The sampling intensity at the 2, 3, 5 and 9 sheep/18 $m^2$ stocking densities was 70, 83, 94 and 98%, respectively. Considering these values, the 5 sheep/18 $m^2$ stocking density was chosen as optimum because of high sampling intensity (94%), without the risk of excessive uniformity (loss of discrimination).

Therefore, in further studies of grazing discrimination/preference in breeding nurseries of red clover, it is recommended to use an equivalent stocking density to 5 sheep/18 $m^2$ for one hour. Either morning or evening grazings could be used.

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**Table 1**
Plant, population and overall heritability of spread, height and leafiness for before-and-after grazing differences and after-grazing plant characteristics using red clover.

| | | Plant | Population | Overall[1] |
|---|---|---|---|---|
| Differences between before and after grazing | Spread | 0.0000 NS | 0.0000 NS | 0.0000 NS |
| | | (0.0000)[2] | (0.0076) | (0.0076) |
| | Height | 0.0000 NS[3] | 0.0055 NS | 0.0055 NS |
| | | (0.0000) | (0.0118) | (0.0118) |
| | Leafiness | 0.0000 NS | 0.0000 NS | 0.0000 NS |
| | | (0.0000) | (0.0422) | (0.0422) |
| After Grazing | Spread | 0.0907 **[4] | 0.2819 ** | 0.3722 ** |
| | | (0.0143) | (0.0979) | (0.0862) |
| | Height | 0.0576 ** | 0.2462 ** | 0.3049 ** |
| | | (0.0088) | (0.0939) | (0.0874) |
| | Leafiness | 0.0000 NS | 0.0676 NS | 0.0676 NS |
| | | (0.000) | (0.0498) | (0.0498) |

[1]See Methods for details
[2]Standard error of Heritability
[3]Not significantly different from zero (P>0.05)
[4]Significantly different from zero (P-0.01)

**Figure 1**
Height (cm), spread (cm) and leafiness (%) after-grazing by sheep for different stocking densities levels with red clover (bars of the same characteristic followed by the same letter do not differ significantly, P>0.05).