

EFFECT OF LEAF AREA ON WHITE CLOVER SEED PRODUCTION

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Abstract. Leaf size is a major determinant of white clover seed yield. A three-fold increase in leaf size halves seed yield. From a survey of commercial crops, an optimum leaf size concept was used to explain the reduction in yield potential for extremes in leaf size. Overgrazing gave small leaves and lowered seed yields. Closing too early gave large leaves and lowered yields. With good management, optimum leaf size was the smallest size possible, consistent with ensuring an adequate bulk for efficient harvesting. A healthy highly-reproductive stolon population has to be developed before closing. Secondly, moisture regulation over the crop season, preventing excess watering to minimise plant exploitation of surplus fertility, reduces the potential for large leaves to develop. Mid-November closing coupled with maintaining soil moisture at about 25% plant available, *over* flowering, are sound management practices.

Amongst cultivars, differences in seed yield potential may also be related to leaf size. In general the larger the mean cultivar leaf size the lower the seed yield.

Keywords: *Trifolium repens*, white clover, seed production, leaf size, soil fertility, moisture, management options.

INTRODUCTION

Recent research by Grasslands Division has emphasised the role of the leaf, particularly its size as a measure of the success or failure of management decisions for white clover (*Trifolium repens* L.) seed production.

Flowerheads form in leaf axils. Therefore leaf development must precede flowerhead formation, and leaf numbers and leaf size required to totally utilise the space available must affect the numbers of florets formed (Clifford, 1980; Thomas, 1961; 1980). Best seed yields are gained from maximum floret numbers per unit area. The formation of large leaves suggests large flowerheads would also be formed, but there would be fewer per unit area. At the extreme, increase in floret numbers per flowerhead in large flowerheads may not offset the reduction in flowerhead numbers. As a consequence, the total floret population would fall (Clifford, 1979, 1980; Thomas, 1981).

Optimum leaf size should therefore be consistent with maximising the total floret numbers formed. But first enough primary stolons are needed to produce sufficient leaves, of optimum size, to utilise the total space over the month of main flowering (December).

Information on this optimum leaf-size concept and the likely effects of management thereon, are presented in this paper.

LEAF SIZE

Optimum leaf size

Results on leaf size effects at peak flowering on seed yield and its major components for a 1978-79 survey of Huia white clover seed crops grown in the Ellesmere District are give in Figure 1. All were first harvest crops from either broadcast or 15 cm row-spaced sowings with ryegrass, cereals or peas. Times from sowing to harvest were 24, 17 and 15 months respectively.

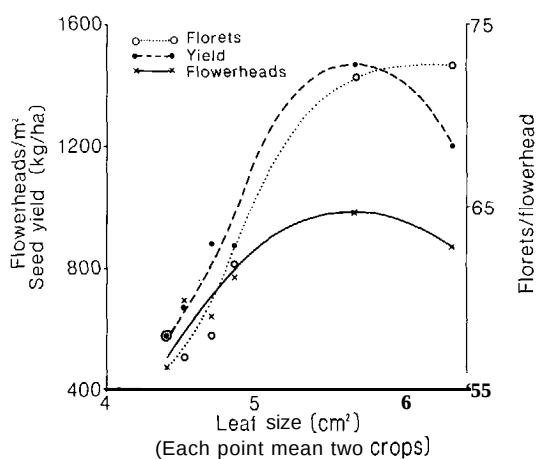


FIGURE 1. Effect of leaf size in survey crops on flowerheads/m², florets/flowerhead and seed yield.

Initially both flowerheads/m² and floret numbers/flowerhead increased with increase in leaf size, verifying the existence of some form of relationship between leaf and flowerhead

size. Floret numbers/m² and seed yield were maximum at a mean leaf size of about 5.6 cm². As a consequence seed yield was also maximised at that leaf size. Increase in leaf size beyond that limit diminished flowerhead numbers/m² and seed yield potential declined from then on. However, floret numbers were little affected and even increased slightly. Therefore, for the normal establishment practices used, there was an optimum leaf size to maximise flowerheads/m² and subsequently seed yield potential.

Soil fertility

For the survey crops, potential harvestable seed yield declined with increase in available soil phosphorus levels (Olsen P test) (Figure 2). However, there was no relationship between available soil phosphorus and leaf size. Therefore for individual crops growers' management rather than soil fertility changed leaf size.

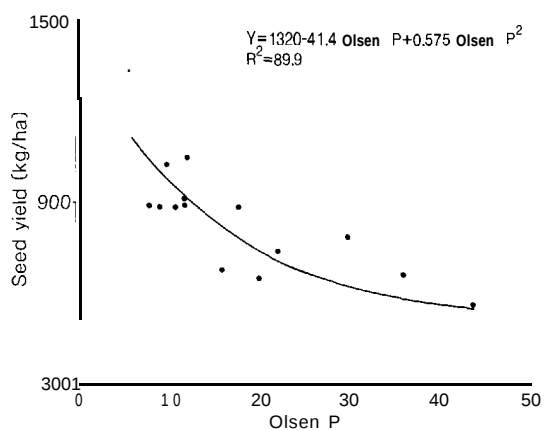


FIGURE 2. Effect of soil phosphorus status on seed yield of Huia white clover.

MANAGEMENT PRACTICES

Seeding rate, method of sowing and time from sowing to closing are the practices that primarily determine optimum plant development. Seeding rate determines plant numbers, method of sowing, space for expression, and time from sowing to closing for plant development. Use of companion species, grazing, spraying, topping, haying, closing date and irrigation, individually but more often in a range of combinations, also affect plant development.

Companion species

Many growers still think of companion species only in terms of reduced costs for clover establishment. Frequently, too little consideration is given to the three important roles they can perform in ensuring optimum plant development at time of closing the crop to flower. They can be used to soak up any undesirable nutritional surpluses, thereby regulating clover leaf growth. Choice of companion species, in relation to the severity of competition desired, allows a degree of flexibility in relation to the time the clover crop is in the ground. Finally herbicide removal of companion species promotes space for clover expression. However, seeding rate of companion species used must be consistent with ensuring initial clover establishment.

Grazing

Removal of primary stolon tips, by grazing, enhances the development of secondary stolons forming along their lengths. Because the secondaries are competing for the same food source, their development will be slower and their leaves smaller. However, these smaller leaves are not necessarily associated with an increase in flowerhead numbers. Should over-grazing occur in the previous autumn only, stolon numbers can become too great, making more critical the timing of closing of the crop to flower. By grazing late-winter early-spring, secondaries may be insufficiently developed to replace the flowering potential of decapitated primaries. Both features were evident in survey crops, which did not yield up to their potential. Thus, sound grazing practice is the removal of leaf only. For high fertility sites, where feasible, the taking of a hay crop to control surplus growth is preferable to grazing. However, a hay crop requires the presence of a vigorous stolon population by the time of closing for hay. This practice has been successfully used in the Blenheim area.

Survey crops (Figure 1) which did not yield up to their environmental capacity fell into two main categories.

1. Those that were overgrazed to counter either high fertility or too high an establishment of clover plants (small leaves).
2. Those that were grazed and closed too early in relation to site fertility and moisture availability (large leaves).

Closing date

Where moisture is non-limiting, mid-November closings maximise total floret numbers. On dryland closing may be earlier to counter the possibility of premature plant stress. Should moisture stress not occur, the plant will continue to use excess phosphate and moisture to develop large leaves. At Lincoln in the 1983-84 harvest season, the effect of closing date on leaf size and flowerhead formation was assessed (Table 1). For both Huia and Pitau white clovers, leaf size declined with delay in closing from mid October to mid November and consequently flowerhead numbers increased. Thus, the lower seed yield from mid-October than from mid-November closings may be attributable directly to differences in leaf size.

TABLE 1 Effect of closing date on leaf size, subsequent flowerhead formation and seed yield.

Closing date	Cultivar			
	Huia		Pitau	
	Mid Oct	Mid Nov	Mid Oct	Mid Nov
Leaf size (cm ²)	9.7 *	1.3	11.2 *	8.9
Flowerheads/m ²	307 *	432	327 *	417
Seed yield (kg/ha)	473	505	471	535

* = P 0.05

Soil moisture,

Water is required by the plant not only to take up soil nutrients but also to ensure that concurrent plant processes are maintained. Restriction of moisture has no effect on leaf photosynthetic activity until wilting point is almost reached (Hagan et al., 1957). Therefore, excessive vegetative growth, and hence leaf size, may be controlled by limiting moisture availability, and hence phosphate uptake.

At Lincoln in the 1980-81 season, for both irrigated and unirrigated crops grown on a uniformly fertile soil, the effect of widely divergent soil moisture retention characteristics on leaf size and subsequently flowerhead formation and seed yield were assessed. During flowering, the higher the soil moisture availability, the larger the leaves (Figure 3). Thus, during flowering, soil moisture is a critical determinant of leaf size. The lesser relationship for irrigated sites was due to rainfall two days before measurement and the time-span was insufficient to stabilise soil

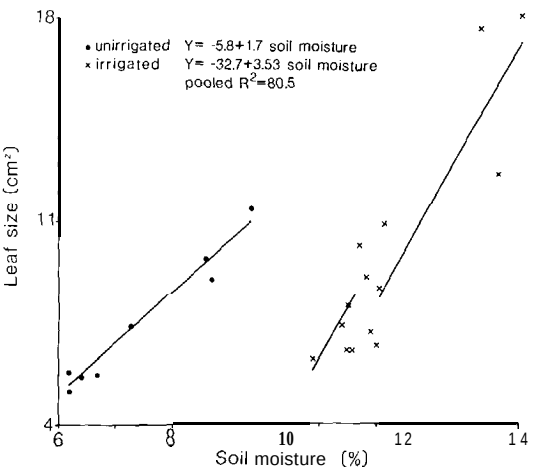


FIGURE 3. Effect of soil moisture on leaf size of irrigated and unirrigated G18 white clover seed crops.

moistures at all sites. In contrast to survey results (Figure 1), an optimum relationship between leaf size and flowerhead--number did not exist (Figure 4). Instead, flowerhead numbers increased with reducing leaf size.

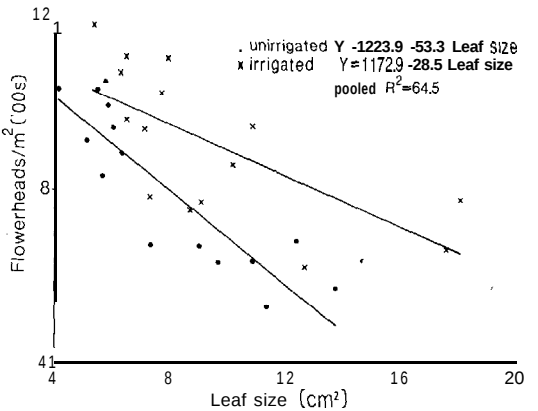


FIGURE 4. Effect of leaf size on flowerhead numbers formed on irrigated and unirrigated G18 white clover crops.

Management was considered responsible for the lack of an optimum leaf size. The crop was autumn-sown at 30 cm spacings without a companion crop and taken for seed in the first year. In early spring, spraying for flat-weed control was followed by surplus leaf removal by topping with a rotary mower as required up to closing in mid-November. Development of a healthy primary stolon population and adequate space for expression were considered to be responsible for the high flowerhead numbers associated with even the smallest leaf size. The optimum leaf size concept can be used to explain extremes in mismanagement only

(Figure 1). If management was sound no restriction in seed yield in relation to reduction in leaf size, was evident (Table 2). For both irrigated and unirrigated crops, leaf size was three times greater where moisture retention was high than where it was low. As a result, seed yields were halved. Therefore, where soil moisture retention is low the grower has more control of phosphate uptake to maximise seed yields.

TABLE 2 Effect of extremities of leaf size on associated flowerhead numbers and seed yield of G18 white clover.

Measurement	Leaf size extremes (cm ²)			
	Dryland		Irrigated	
	Lowest 4.1	Highest 13.8	Lowest 5.3	Highest 17.7
Flowerheads/m ²	1030	570	1180	660
Seed yield (kg/ha)	1020	520	1080	600

Irrigation

The results from G18 white clover to date suggest that the greatest advantage from irrigation is on soils low in phosphorous (Olsen P 6-10). In such soils detrimental effects of over-irrigation and/or untimely rainfall will be minimised by the limited phosphate supply for plant uptake. Soil moisture requirements for a high-yielding crop should be maintained at about 25% plant available. Where practical no application should exceed 50% plant available, unless on a free-draining soil (Hagan *et al.*, 1957; Clifford, unpub. data).

Two trials at Lincoln highlight the extremes of irrigation practice (Clifford 1977; unpub. data). Both were sown in a fertile Wakanui silt loam requiring 50 mm of water from wilting to field capacity. Trial 1 irrigation treatments were: None; 50 mm at closing; 50 mm at closing + 50 mm in mid January. At closing, in mid-December, soil moisture was more than adequate to sustain a good flowering response.

TABLE 3 Effect of over irrigation on seed yield

Cultivar	Treatments		
	None	50 mm closing	50 mm closing + 50 mm mid Jan.
Huia	444	378	252
Pitau	309	240	122

Data from Clifford (1977).

The results of this trial emphasise the costly exercise of over-watering (Table 3). Each addition of water reduced seed yield.

In contrast, trial 2 showed the advantages of irrigation on a white clover crop that was closed to flower in mid-November (Table 4). From mid-December, when soils were near wilting point, until mid-January, either no water or 25 mm water (50% plant available) was applied weekly (total of 6 irrigations). Before each application soil moisture was near wilting. For both irrigated and unirrigated crops there was adequate bulk for harvesting.

TABLE 4 Effect of maintaining soils at 25% plant available on seed yield and major components of G18 white clover.

	Treatments	
	Dryland	Irrigation
Seed yield (kg/ha)	570	830
Flowerheads m ²	810	950
Seeds/flowerhead	118	144

Clifford (unpub. data).

Irrigation increased seed yield by 45%. More than half the advantage was because all fertilised ovules were carried through to maturity. Therefore, sound irrigation practice is consistent with growing crops with small leaves, thereby increasing number of flowerheads per unit area, and maximising the numbers of fertilised ovules taken through to maturity (Clifford, unpub. data). Crops should be sown where fertility is low to medium (Olsen P 6-15) and watered on a basis of no more than 50% plant available where possible.

CULTIVARS

At Lincoln, in the 1982-83 season, leaf size at peak flowering relationships with flowerheads/m², florets/flowerhead and seed yield were measured for autumn sown crops of Huia, Pitau, Tahora and G18 white clovers that were closed to flower in mid-November of the sowing year. These results showed that the within-cultivar variations attributable to leaf size also happened amongst cultivars of differing mean leaf size (Figure 5). The larger the cultivar mean leaf size the fewer the flowerhead numbers (Figure 5A) and the greater the numbers of florets/flowerhead present (Figure 5B). However the increase in florets/flowerhead was insufficient to offset amongst-cultivar differences in their leaf size/flowerhead numbers relationship.

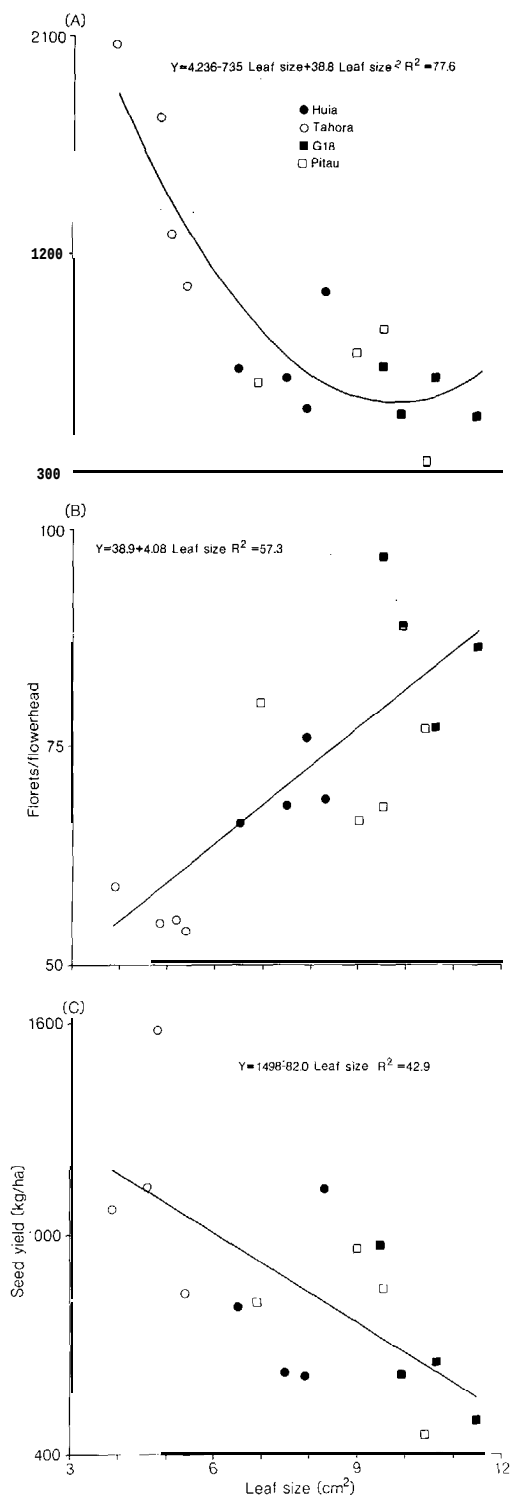


FIGURE 5. Effect of leaf size on (A) flowerheads/m² (B) florets/flowerhead and (C) seed yield amongst white clover cultivars.

Consequently again seed yield declined, but this time with increase in mean cultivar leaf size (Figure 5C). However, for this trial no strong relationship was gained.

Thus, overall seed yield potential for a particular cultivar could be related to its mean leaf size — the larger the leaf the lower its yield potential. Therefore, for large compared to small-leaved cultivars optimising seed yield through limiting leaf size becomes an obvious necessity. This feature is apparent from the leaf size/seed yield relationships for G18 (Table 2). Further, the overall results suggest that if the parent plants which constitute the cultivar are widely divergent in leaf size, then genetic deterioration will occur with each successive increase away from the nucleus seedline. Any genetic dilution will favour the smaller leaved component.

CROPPURITY

When the leaf size-of contaminant white clover plants established from the buried seed load is similar to that of the sown cultivar, any practice aimed at reducing leaf size would be expected to give a directly proportional effect on the physical dilution of the resultant seedline. If the sown cultivar leaf size is much larger, then per-contaminant contribution to dilution may be significantly increased.

Only a rudimentary indication of the likely effects of management reducing leaf size and modifying the contribution to seed yield of a small-leaved contaminant in a large-leaved crop is available. A comparison of Tahora : G18 ratios for **flowerheads/m²** at the extremes in leaf size tends to favour proportionately more extra flowerheads being formed on G18 than Tahora for the greatest reduction in leaf size. However, this feature was not reflected in a potential for a reduction in the percentage contamination of a resultant seedline. Therefore the very limited information available- indicates that management **reducing** leaf size seems to have no effect on altering the contribution of contaminants to seed yield. More detailed research on these aspects is continuing. However, the most obvious solution is to sow a similar or smaller leaf-size cultivar if the possibility of contamination is suspected.

All management practices are geared to minimising leaf size. Therefore contaminant identification, apart from row-spaced crops,

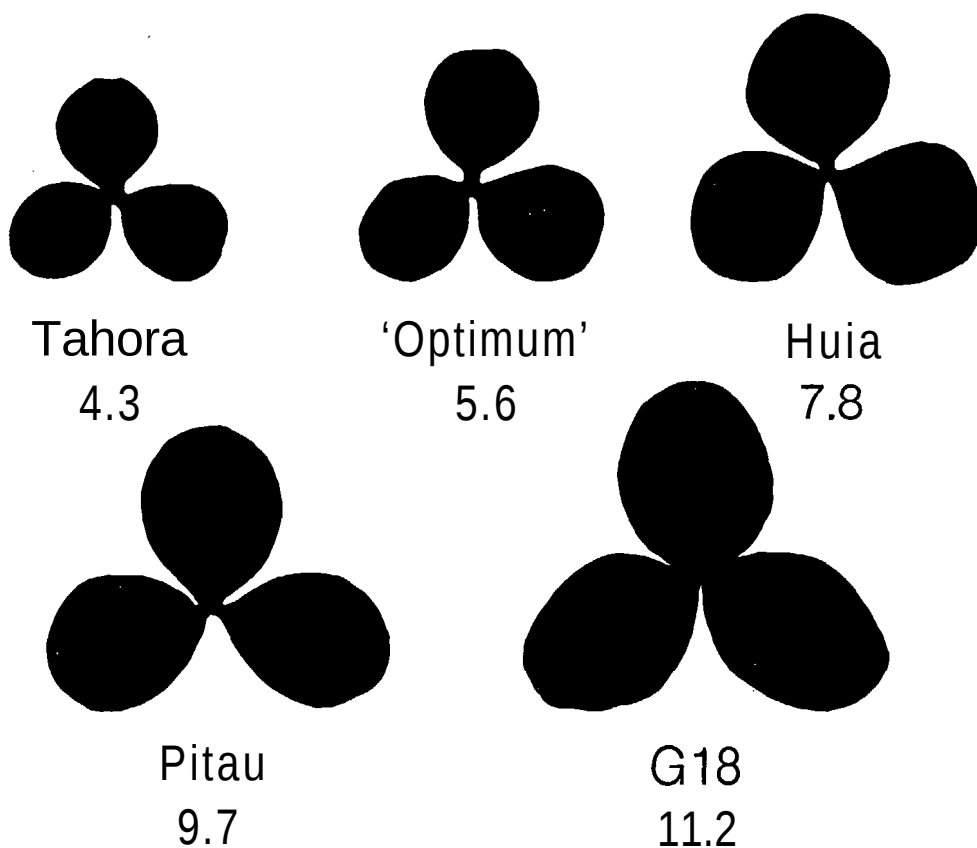


FIGURE 6. **Diagrammatic** portrayal of actual leaf sizes for Farm Survey Optimum and the four NZ bred cultivars. (Figures = mean leaf size cm*).

becomes a far greater problem. As such, regular inspections for and removal of contaminants must be done over the establishment period, when the greatest level of genetic expression is present.

ACTUAL LEAF SIZE

To allow both growers and researchers to relate these results to their own situation Figure 6 gives life-size drawings from actual leaves. These depict the optimum from the farmer survey (Figure 1) and the mean leaf sizes from the cultivar comparison (Figure 5).

CONCLUSIONS

Regardless of cultivar, leaf size is a major determinant of white clover seed yield. An optimum leaf-size concept provides a simple explanation of only mis-management practices. With good management a crop should produce the smallest leaf possible while ensuring adequate crop bulk to promote efficient

harvesting. Two points are important: Firstly, a healthy highly-reproductive stolon population is needed. Secondly, moisture control is important in regulating leaf size during flowering. The choice of closing date can be used to regulate moisture, but closing later than mid-November will decrease seed yields. Flowerheads removed when closing later than mid-November are not replaced. Thirdly, where a change in cultivar grown is envisaged, if possible choose a smaller leaved cultivar to minimise contamination potential.

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DISCUSSION

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| <p>Q. What is the effect of reducing leaf-size by management on 1000-seed weight?</p> <p>A. Within cultivars, very little. However, it must be realised that genetically smaller-leaved cultivars (Tahora) normally have lower 1000-seed weights.</p> <p>Q. Please comment on the use of 2,4-D butylester.</p> <p>A. This herbicide is applied primarily to reduce suckling clover contamination. Its action on white clover tends to reduce both leaf size and herbage bulk for harvest. Consequently more flowerheads formed associated</p> | <p>with better timing of harvest, frequently gives higher seed yields.</p> <p>Q. With grazing to reduce leaf size, will farmers end up with clovers of a similar leaf size, which will make it very difficult for MAF inspectors to tell one cultivar from another?</p> <p>A. No, because the current MAF regulations require four inspections, some of which will be before grazing is imposed when leaf differences between cultivars will still be obvious.</p> |
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