Research in white clover seed production

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ABSTRACT. White clover seed yields from crops derived from pure autumn broadcast sowings harvested in the first year after sowing were improved by increasing sowing rate from 3 to 6 kg/ha. On moisture-retentive soils or where irrigation was available, mid-November closings gave highest seed yields for crops derived from either spring undersowings of cereals or as ryegrass mixtures taken for ryegrass seed in the first year from sowing. Closing a month earlier gave similar yields if 30 cm rather than 15 cm row spacings were used. Harvest should be no later than one month from main flowering to reduce the numbers of seedheads lost. General management should aim to promote good primary stolon growth rates over the month prior to mid-December if high flower-head densities are to be obtained. Therefore excessive grazing before closing and poor timing of herbicide spraying for grass control should be avoided.

Key words: *Trifolium repens*, seed production, plant density, closing date, pollination, seed harvesting, management.

PRINCIPLES GOVERNING CROP MANAGEMENT

Recent research by Grasslands Division at Lincoln, Canterbury, highlights the importance of understanding the management requirements of the white clover plant (*Trifolium repens* L.) if the farmer is to obtain high seed yields.

'Continuing vegetative development of "plants provides an increasing number of sites (nodes) where either stolons or flower heads can occur. The rate of plant development is influenced by crop management, although the overall extent of plant development is determined by the time from sowing to harvest. Thus sowing rate must take both factors into account (Clifford, 1977).

Flower-head density is the major component of seed yield and is associated with the rate of head appearance during the month of main flowering (Clifford, 1977, 1979). Therefore the major objective of good management for seed production is to promote maximum node and subsequent flower-head development over the shortest time span to ensure high yields and minimum seed loss at harvest. High temperatures and long days result in high rates of node and flower-head development (Thomas, 1961; Brougham, 1962).

Determining the time of closing the crop to flower must take account of the duration of rapid growth subsequent to stock removal, because flower-head appearance is related to leaf appearance (Thomas, 1961). Rapid growth rates for pure stands defoliated in early November were maintained for only 5 weeks (Brougham, 1958). Thus optimal date of closing in relation to the longest day would seem to be mid-November (Clifford, 1979). Earlier closings may be possible when stolon-tip density is lower than that associated with a mature stand. The greater distance between stolon tips would result in an increase in the rapid growth period. Increasing the distance between rows rather than reducing the sowing rate may be a more reliable practice for extending the rapid growth period. The former would allow higher rates within the row to overcome fluctuations in seasonal and management patterns and would thus ensure an adequate stolon-tip density by closing date. Further, wider row spacing than the normal 15 cm would allow inter-row cultivation or spraying to curtail plant colonization as well as reducing the risk of possible contamination from progeny of buried seed (Clifford, 1977).

Of necessity, most of our research to date has been done in plots with hand-harvested seed. However, ideas obtained may now be used by growers provided that more attention is paid to general pre-closing management and harvesting techniques than at present carried out.

TABLE I: HAND-HARVESTED SEED YIELDS F KOM ROW-SPACED HUIA WHITE CLOVER CROPS (kg/ha)

Sowing Rate (kg/ha)	ROW Spacing (cm)	1st-year Harvest Mid-Oct. Closing		1st-year Harvest Mid-Nov. Closing	2nd-year Harvest† Allowed to Run		2nd-year Harvest† Inter-row Cultivated
6	15	740	*	940	340		—
		*					
3	30	850		880	440	*	517
		*		*			
2	45	690		670	430	*	562

* ($P < 0.05$).
† Treatments closed in mid-November.

THEORY TO PRACTICE

PLANT DENSITY

A survey of growers' crops over 1977-79 indicated that the usual 3 kg/ha sowing rate of clover seed seemed sufficient where clover was sown in a mixture with ryegrass or spring undersown on a cereal crop with clover seed to be taken in the second productive season. However, if harvesting is intended in the first year from sowing, higher sowing rates are worth while. For instance, after autumn broadcast sowings of Huia and Pitau white clovers at 3 and 6 kg/ha, both clovers yielded 510 and 600 kg/ha of seed, respectively — a gain of 90 kg/ha for an additional 3 kg/ha at sowing. No greater yield could be obtained through a further increase in sowing rate (Clifford, 1977).

A comparison of 30 and 45 cm row spacings with the normal 15 cm autumn drillings first harvested in the year of sowing gave lower yields only at 45 cm spacings (Table 1). After the first harvest, plants in half of each 30 and 45 cm spaced plot were either allowed to colonize the inter-row space or maintained at original spacing by inter-row cultivation until closing. At the second harvest, where stolons had been allowed to colonize the inter-row area, both 30 and 45 cm spacings gave a 26% increase over 15 cm spacings. However, where wider than normal spacings had been maintained through inter-row cultivations, increases compared with 15 cm spacings were 52% and 65% for 30 and 45 cm spacings, respectively. This result highlighted the benefit of curtailing additional increase in plant density after first harvest when a second crop is contemplated. In a similar trial, but at quarter of the sowing rate, wide row spaced Pitau crops gave only 65% of the yield of Huia at first harvest but 36% more at second harvest. The lower yields for Pitau at first harvest were attributed to a slower rate of plant development (Clifford, 1977). Therefore sowing density may have to be adjusted according to the development rate of the cultivar, more so when a first-year harvest is contemplated.

CLOSING DATE

In order to ensure enough vegetative bulk to facilitate harvesting of the crop, many farmers close early. In areas where moisture limits plant growth this is a sound practice, for it effects the best compromise between seed harvested and seed lost in relation to the total amount of seed set. Grasslands Division research showed that, with adequate soil moisture, deferring closing to mid-November gave highest seed yields, while a further delay of a month gave a drastic reduction (Table 2). For mid-December closings no improvement could be made to seed yield by irrigation. Although numbers of flower heads were similar

TABLE 2: EFFECT OF CLOSING DATE ON SEED PRODUCTION OF WHITE CLOVERS
(Relative to mid-November closing = 100)

	Mid-Sep.	Mid-Oct.	Mid-Nov.	Mid Dec.
Seed yield	87	85	100	46
Numbers of flower heads	63	74	too	62

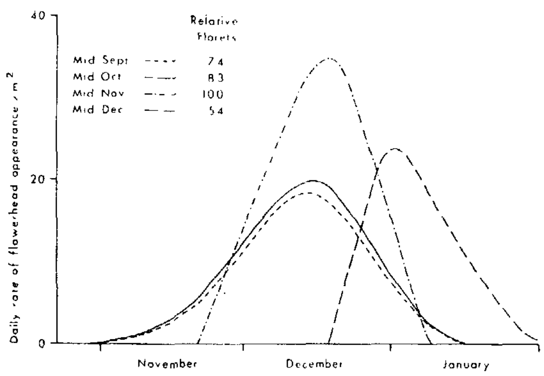

FIG. 1: *Effect of four closing dates on rate of flower-head appearance in a Huia white clover crop. (Relative florets derived from means of florets/flower head X flower-head density.)*

for September and December closings, reductions in numbers of florets/flower head and individual seed weight with each delay in closing were responsible for most of the 47% reduction in seed yield observed (Clifford, 1979). The best balance between flower-head number and yield per flower head was achieved from mid-November closings. The concentrated flowering following this closing also meant that potentially more seed could be harvested from mid-November than from other closing dates (Fig. 1) . Earlier closings resulted in loss of early-formed heads through deterioration, under the canopy. Later closings contained a much larger percentage of heads supported by short stalks which were subsequently lost at harvest.

In areas where rainfall patterns, in the absence of irrigation, demand earlier closings, mid-October closing for 30 cm row spaced crops gave similar yields to those from November closed 15 cm row spacings at first harvest (Table 1). This result was a consequence of the longer time taken to reach full canopy at the wider row spacing. Thus both crops had high growth rates over the critical mid-November/mid-December period. By contrast, mid-October closings at 15 cm row spacings gave only 86% of the flower-head production of 30 cm spacings because of earlier canopy closure. Once again these results highlight the advantage (27%) of delaying closing until mid-November for normal row spaced crops.

POLLINATION

One honeybee working each square metre or one hive for each 3 ha of flowering crop has been shown to be adequate to gain good yields (Forster, 1974). However. as bees forage up to 1.5 km in any direction from the hive, numbers of hives needed should take into account all crops and other colonies sited within this zone to ensure satisfactory pollination.

HARVEST

Within the range of closing dates shown to give good seed yields, main flowering occurred during December, with a month elapsing from pollination to seed maturity (Hyde *et* al.. 1959) . Therefore, even when soil moisture remains adequate for growth it is not advisable to delay harvest beyond late January/early February to gain later-formed heads, because of the risk of losing early-formed seedheads.

Modern harvesting techniques involving the use of crop desiccants enable rotary and double reciprocating knife mowers to travel at speeds well in excess of the limits imposed by a green crop and traditional lespedeza bar, which greatly increases the potential for seed losses at harvest. Preliminary investigations into harvest losses where sicklebar or rotary mowers had been used on desiccated crops indicated that, on average, 30% of the seed is left on the paddock. This is not only a considerable economic loss but also a source of contamination for future crops.

GENERAL CROP MANAGEMENT

Grazing management should aim at retaining a high number of vigorous primary stolons within the stand, overgrazing leading to the development of a large number of weaker secondary and tertiary stolons. Grazing after mid-September when flower heads are initiating should be carefully controlled to minimize flower-head removal. Topping with a mower or grazing with cattle rather than sheep provides better height control when removing leaf. However, when crop bulk is large, there is the obvious problem of trash left after topping. In this respect topping is more appropriate for less bulky row spaced crops.

Spraying with herbicides is another feature of management that may affect the crop. Paraquat is often sprayed too late to control grass weeds, and in extreme cases late application can depress white clover growth and subsequent flowering. An alternative method is the winter application of carbetamide and propyzamide. Spraying carbetamide in June compared with paraquat at the beginning of November gave a 25% or 220 kg/ha increase in seed yield in the following summer. Cool weather conditions in November markedly reduced the recovery of clover after spraying so that paraquat gave 10% less in seed yield than unsprayed crops (H. Butler, pers. comm.) . Experience over recent cool springs indicates that paraquat should be applied by early October to avoid possible depressions in seed yield.

In the past season 22 crops were surveyed in the Lincoln-Leeston area to assess the effect of a range of alternative techniques for managing white clover seed crops. Highest seed yields overall (900 kg/ha hand-harvested) were obtained at a stolon-tip density of 3000 to 4000/m”, but there were large differences owing to grazing and spraying practice.

Seed yields were measured on two stands derived from Huia/Manawa ryegrass autumn drillings which had been grazed up to September when one-half was removed from grazing for a ryegrass seed crop. From the following March until closing for white clover seed in mid-November, both halves were grazed together. Results showed that clover seed yields following ryegrass seed production were 36% or 260 kg/ha higher than those for crops grazed throughout (Table 3). At closing, stolon-tip density was 10% lower on grazed paddocks (mean of two seasons), which also contained more secondary and tertiary stolons of lower vigour. This result indicated that even under the prudent grazing management practised on this property a considerable drop in seed production potential occurred.

General crop management is capable of effecting vast differences in seed yields gained depending on the system chosen. For instance, research crops which were autumn sown at 30 cm row spacings and only topped with a mower, as required, up to closing for seed in mid-November of that year achieved a stolon-tip density of $400/m^2$ but subsequently gave yields of 880 kg/ha (Table 1). To gain similar yields from crops using current farmer management practices, an up to tenfold increase in stolon-tip density was required. This large difference highlights a need for more knowledge to find the best range of management practices.

TABLE 3: EFFECT OF GRAZING MANAGEMENT ON HAND-HARVESTED SEED YIELDS (kg/ha) OF HUIA WHITE CLOVER

	Grazed to Closing Date		*Ryegrass Seed Crop*
Pdk 1 (1977-8)	900	*	1200
Pdk 2 (1978-9)	*880*	*	1100

* (*$P < 0.05$*).

CONCLUSIONS

Major points from our research are:

1. Under current sowing practices, closing mid-November gives highest seed yields on moisture-retentive soils or where irrigation is available.
2. Earlier closing, which may be desired because of uncertain weather, can give high seed yields if 30 cm row spacing is used.
3. Optimum harvest date is late January/early February in good seasons.
4. Graze lightly or top prior to closing so that mainly leaf is removed and most flower heads remain intact.
5. Spraying for grass weed control must be sufficiently early so that clover growth in the month of main flowering is not reduced.

ACKNOWLEDGEMENTS

Sincere thanks are offered to collaborating farmers and the staff of the Lincoln College Mixed Cropping Unit for discussion and use of crops.

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