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HERBAGE SEED: PRODUCTION AND RESEARCH — A REVIEW OF 50 YEARS

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Abstract

By 1938 a small herbage seed industry was well established in New Zealand after the introduction of a system of seed certification and the establishment of a Government plant breeding station. Production increased rapidly during the 1940s, to level off and fluctuate around 22,000 tonnes annually. Perennial ryegrass and white clover now dominate production. and research on these 2 species is presented to illustrate advances in research and practices of seed production. In ryegrass over the last 50 years we have gained an understanding of the physiology of flowering, and the use of herbicides, fungicides, nitrogen fertiliser, plant growth regulators, and post harvest drying systems are widespread. In white clover, growth and the detrimental influence of high soil fertility and/or soil moisture are now understood. Pollination and insect pest control, grass removal, and causes of harvesting losses have been studied and incorporated into seed production.

Keywords: herbage seed, perennial ryegrass, white clover

INTRODUCTION

Herbage seed production in New Zealand dates more than 100 years, with exports in the 1880s of 1400 tonnes of grass seed: cocksfoot, ryegrass *(Lolium* spp.) and tall fescue (Festuca arundinacea) (McKay 1887). Problems of poor seed quality and lack of strain uniformity in the 1920s resulted in 1929 in a system of seed certification for grasses and clovers (Eaden 1980; Hampton 1984). Plant breeding of grasses and clovers began with the establishment in 1927 of a Government plant breeding station at Palmerston North, resulting in three cultivars being released in the early 1930s (Rumball 1983). The cultivars later became known as ‘Grasslands Huia’ white clover *(Trifolium repens)*, ‘Grasslands Ruanui perennial ryegrass *(Lolium perenne)* and ‘Grasslands Turoa’ red clover *(T. pratense).*

Thus the stage was set in the late 1930s, the beginning of this 50-year review period. Seed production was 7300 t in 1938, but it increased rapidly in the 1940s to level off and fluctuate around 22000 t, with a declining trend beginning in 1976 (Table 1). The growth in volume has been associated with two species, perennial ryegrass and white clover. Volumes of other species have been static or have declined; crested dogstail *(Cynosurus cristatus)*, 1240 t (1947) to 200 t (1986); Chewings fescue *(Festuca rubra)* 1534 t (1947) to 11 t (1983) and also hybrid ryegras *(Lolium x boucheanum),* cocksfoot, red clover, lucerne *(Medicago sativa).*

In a review of the herbage seed industry Rolston *et* al. (1988) reported a farm-gate value of herbage seed of $NZ40 million. Seed exports are a major component of the industry averaging 7500 t (1982/86; 14000 t in 1987). Seed is exported to more than 30 countries, the major markets being the EEC, Australia and the USA

This paper reviews research on herbage seed using two species, perennial ryegrass and white clover, to illustrate advances. Average yields of these well researched species have increased, but are still low compared with those of good specialist growers and the best research yields (Table 2).

Table 1: **Quantities of machine dressed herbage seed produced in New Zealand (1000 t/year)**

Period	Total	Ryegrass Perennial + hybrid	Ryegrass Annual	Cocksfoot	Clover White	Clover Red	Other
1938-42	11.8	6.5	1.6		0.7	0.8	1.4
1943-47	18.5	6.8	3.3	1.0	1.8	1.4	2.4
1948-52	20.5	11.9	1.2	0.6	2.6	1.5	2.7
1953-57	23.0	15.4	1.1	0.5	2.7	1.1	2.2
1958-62	17.7	11.2	0.9	0.7	2.2	1.0	1.7
1963-67	25.6	16.5	1.8	0.9	3.4	1.1	1.9
1968-72	24.7	15.2	2.5	1.0	2.5	0.9	2.5
1973.77	22.8	13.0	3.0	0.6	3.9	0.8	1.5
1978-82	20.8	11.2	1.8	0.6	5.4	0.7	1.1
1983-87	19.1	9.8	2.1	0.4	5.5	0.5	0.8

Table **2: Trends in national seed yields (kg/ha) compared with good specialist growers and research**

Species	National average 1942-44	National average 1984066	Good specialist grower	Research+'
Ryegrass	350	585	1 ZOO-1 500	2900 (1)
Cocksfoot	140	305	600- 900	1350 (2)
Browntop	135	135	300- 500	750 (3)
White clover (huia)	120	230	500- 900	1330 (4)
Red clover (Hamua)	140	160	400- 800	1230 (5)

• **Higher specialist yields have been achieved but not consistently.**

• *** Hand harvested.**

(1) Hampton et al. 1985.
(2) Rolston & Hare 1986(a).
(3) Rolston 8 Hare 1986(b).
(4) Clifford 1985(a)
(5) Clifford 1979(b)

PERENNIAL RYEGRASS

A detailed management guide for perennial ryegrass seed production in the 1950s (Garrett 1957) illustrates the state of knowledge then. Herbicides were not discussed, and the importance of fallows to keep land clean of weeds was highlighted. Seeding rates of 22 kg/ha were recommended, although rates of 33 to 44 kg/ha were still being used. Overgrazing was noted as a problem to avoid, with recommendations that crops should be closed no later than 1 September in drier areas and mid September in others. Nitrogen fertiliser was recommended, but Garret notes only a relatively small scale use of nitrogenous fertilisers.

Discussing the difficulties of determining the time of cutting, Garrett notes the popular method of sweeping a hat through the crop and examining the number of seeds caught, and commenting "if a large number [of seeds] fall [into the hat] it should have been cut two or three days previously". He notes that under normal conditions the seed stalks are standing (a sure sign of a light crop by today's standards). The crop was either cut with a binder or mown into a windrow, left for a minimum of 7- 9 days, and harvested into bags which were allowed to field dry, weather permitting.

Physiology of flowering

Initial research focused on the physiological processes governing seed production with work by Hill (1971, 1980) and Langer (1972) on the origin, position and contribution of individual tillers, which laid the foundation for management research.

Sowing and grazing

Sowing rates of 20 kg/ha are still common, but specialist growers have reduced their sowing rates to 8-12 kg/ha Most crops are established with white clover. The grazing recommendations of Garrett (1957) including time of closing (mid September) for most areas are unchanged.

Fertiliser

Research on the role of nitrogen rates and timing in seed yield and components by Field-Dodgson (1971) illustrated the importance of increasing seed head number as a component of increased seed yield. Brown (1980) introduced the time of N application with the concept of "elongation N". The use of autumn N, although initially advocated (Hill 1972), generally did not enhance seed yields in subsequent trials (Rolston et *al.* 1985). Hampton et *a/.* (1985) suggested grass seed crops require 130 kg N/ha, and the need to determine soil residual N status as a component was recognised. Other elements have rarely been reported as limiting grass seed yields in New Zealand.

Weeds

Weeds as contaminants lowering seed quality have always been a problem, and the 1969 Weed and Pest Control conference had a 5-paper session on weed seeds in agriculture, including control methods in the field (Allen 1969); and seed cleaning (Hartley 1969). Noxious weeds such as wild oat (*Avena fatua*) (Allen et *al.* 1974) and nodding thistle (*Carduus nutans*) are still problems in some crops (Rolston *et* al. 1985). Most farmers use various herbicide mixtures for cereals on grass seed crops, and as a result the three most commonly occurring weeds in seed lots are annual grasses, soft brome (*Bromus mollis*), vulpia hair grass (*Vulpia* spp.) and annual poa (Poa *annua*) (Rolston et *a/.* 1985).

Diseases and fungicides

Latch (1980) reviewed diseases in herbage seed crops. Blind seed disease (*Gloeotinia temulenta*) was a significant problem in the 1940s but since 1957/58 only minor infections have occurred and this decline has been associated with increased use of nitrogen fertiliser, which suppresses apothecial formation. Stem rust (*Puccinia graminis*) is a more recent problem in New Zealand. The disease can lower yields by 5 fold (Latch & Christensen 1988). A range of cereal fungicides gave excellent control. Even in the absence of leaf disease Hampton (1986a) reported increased seed yields with fungicides, associated with retarding leaf senescence and improved floret fertility. The use of fungicide applied immediately pre-flowering is now recommended.

Plant growth regulators (PGRs)

There has been strong interest in PGRs for manipulating grass seed crops since early trials on paclobutrazol showed enhanced yields associated with reduced lodging and increased fertile tiller density and seeds per spikelet (Hampton et al. 1985). The chemical has yet to be registered for seed crops in NZ, but became commercially available for horticulture in 1987. A re-evaluation of the effects of chlormequat chloride (CCC) showed consistent yield increases from 1.5 to 3.0 kg a.i./ha applied at stem elongation (mid to late September for most ryegrasses) (Hampton 1986b). The yield increase is not associated with lodging control. CCC was registered for ryegrass seed crops in 1987.

Seed moisture, harvesting and drying

The optimum time for cutting can be determined by seed moisture (42-45%). The move to bulk heading in the late 1950s led to some disastrous germination collapses from fungal (*Aspergillus glaucus*) heating. Crosbie (1980) pioneered the design of drying systems so that seed could be cooled and dried to 14% seed moisture for safe storage.

Seed recovery

Early research (Langer 1980) emphasised the importance of achieving an optimum seed head density. Once optimum densities of 2000-2500 heads/m^2 were being achieved Brown (1982) noted considerable variation in seed yield associated with the number of florets producing a saleable seed. Brown (1982) referred to this as seed recovery which ranged from (15-20%), and much of the response to fungicides, PGR and nitrogen is explained by increasing seed recovery.

WHITE CLOVER

The first production boom started in the mid 1940s and came from ryegrass-white clover sowings, with the use of header-harvesters markedly reducing the high pre-war seed losses associated with stacking for later threshing by a clover huller (Leitch 1949). In the mid 1940s 18 000 ha, compared with 15 000 ha now, were taken for seed. However, the national average seed yield was only 80 kg/ha compared with today's 230 kg/ha. Post war, 400 kg/ha was the upper limit of grower expectation, but commercial yiels are now reaching over 900 kg/ha (Table 2). These major yield differences between the past and the present highlight the effect of research findings on crop management.

In the late 1950s grass grub and porina control with DDT reduced subsequent pasture loss associated with closing a field for seed. Proude (1965) showed that control of high infestations of casebearer moth could double seed yields, while Palmer-Jones et *al.* (1962) defined minimum hive density for pollination at 1 per 3 ha (later revised to 1 per ha – MAF 1986). Removal of grass competition by paraquat spraying increased seed yields by 400% depending on grass density in relation to timing and application rate (Leonard 1964). Minimising the higher loss potential in these pure clover, low bulk crops, was overcome by the development of the Murphy rotary-tyned pickup.

Clover growth physiolgy

The first agronomic paper on the influence of the environment on white clover seed production (Thomas 1961), was significant in laying the foundation from which Clifford worked. His research culminated in the development of a philosophy which has promoted grower understanding to a level whereby the limitations of a particular environment can be minimised.

Clover growth occurs at the stolon tip with either stolons or flowerheads, but never both, forming in leaf axils (Thomas 1961). Thus flowerhead-associated leaf numbers in the mature crop are related directly to seed yield (Clifford 1985a, b, 1986b, 1987). Floral induction is promoted by low temperature and short days, which is the opposite to floral expression (Thomas 1961, 1980). Seed crops must (i) experience a winter, (ii) have sufficient space among plants to grow high numbers of flowerhead-associated leaves, which must be ensured by, (iii) minimising any deleterious effects of excess soil moisture and/or fertility in increasing leaf size at the cost of lowering seed yield (Clifford 1979, 1980, 1985a, b, 1986a, b, 1987).

Research has shown how to meet these requirements in some of the following ways. Autumn row-spaced sowings (30-45 cm) have (i) increased flexibility of the crop rotation; (ii) ensured space for floral expression; (iii) given economic returns from soils with higher than desirable moisture-holding capacity and/or high soil fertility, especially P levels; and (iv) enabled elimination of inter-row contaminants, thereby allowing cultivar change to meet market demands (Clifford 1977, 1979a, 1980, 1985a, 1985b, 1987; Clifford et *al.* 1985; McCartin 1985; Hampton et al. 1987; Seed Certification, Seed Quality Control, MAF, 1984). By using moisture-retentive soils or irrigation the grower can close the crop to flower in mid November, thereby optimising flowering intensity around the longest day (Clifford 1979).

Irrigation after closing should be applied at any sign of wilting to maintain growth (flowering) and fertilised ovule retention; application rates should be about 50% of moisture holding capacity (Clifford 1985a, 1986a, 1986b).

The combined effects of this research have been to rapidly increase the area of seed taken on lower fertility (Olsen P=6-1 2), free-draining irrigable soils (Freeman 1985). In this way, the effects of high fertility on increasing leaf size, which diminishes both flowerhead numbers and yields, are more easily controlled (Clifford 1980, 1985a, 1987). Additionally for these soils, the implied growth control has lessened the spring grazing requirement, thereby reducing fertile stolon tip loss at the additional expense of developing further competitive infertile stolons (Clifford 1980, 1987).

The quantifying of when, where and why seed losses occur from the range of machinery alternatives and harvesting processes used, has greatly improved grower understanding of the best choices in relation to crop condition at harvest (Clifford & McCartin 1985).

CONCLUSION

Research has now provided the technology whereby the national average seed yields of ryegrass and white clover should be 1200 and 600 kg/ha respectively rather than the present averages, which are less than half of these. In looking to the future Rolston et *al.* (1988) have suggested the herbage seed industry has to be competitive internationally if it is to grow. Producing high yields which generally have low costs per kg of seed using the technologies discussed is an important component of being competitive internationally, Other components include producing appropriate cultivars that are on Recommended Lists, and protected by Plant Variety Rights; maintaining high quality seed lots; having effective marketing, with national off-farm costs that are similar to those of competitors; and maintaining a technological edge with research programmes.

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