National and export trends in herbage seed production

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Abstract

The viability of the New Zealand herbage seed industry is influenced by national and international factors and changes in consumer requirements. Four main species perennial ryegrass (*Lolium perenne)*, Italian ryegrass (*Lolium multiflorum*), tall fesuce (*Festuca arundinacea*) and white clover (*Trifolium repens*), account for more than 98% of the herbage seed grown in New Zealand. Annual production averages 22000 t, of which 70 to 80% is grass seed with perennial ryegrass (*L. perenne*) being the largest component. There have also been significant production changes among species with Italian ryegrass (*L. multiflorium*) in particular increasing in importance, with production doubling between 1999 and 2003. There has been a marked reduction in total area for herbage seed production over the past decade, however, this has been offset, particularly in ryegrass, by higher seed yields per ha. These improvements in seed yield have primarily been achieved through implementation of better management techniques. The increased use of the plant growth regulator trinexapac-ethyl has been very beneficial in grass seed production. There has also been a major shift in New Zealand seed production towards the production of proprietary cultivars. In white clover, for example, proprietary cultivars represented less than 10% of production in 1991 but have increased to 57% in 2003. The rapid uptake of the novel AR1 endophyte technology in proprietary ryegrass cultivars, which has grown from 0% in 2000 to 21% of perennial and hybrid proprietary ryegrass seed produced in 2003, is an excellent example of what can be achieved with an added-value product. The future viability of the New Zealand herbage seed industry requires further development of identifiable added value traits associated with the seed.

Keywords: AR1 endophyte, plant growth regulators, production statistics, ryegrass, seed production, tall fescue, white clover

Introduction

The herbage seed industry in NZ is dynamic and is influenced by changes in international and national agricultural policies and consumer perceptions. Herbage seed exports are currently worth $60m per year and these exports rely on a stable trading position (exchange rate and non-tariff trade barriers) and a stable production base in order to be internationally competitive. Herbage seed production is also influenced by the profitability and reliability of alternative land use options. Herbage seed production in NZ has reduced in part due to the increase in dairy farming in Canterbury. Conversion to dairy farming has directly reduced the number of seed production/mixed cropping enterprises, and has resulted in further arable land being used to grow supplementary feed and provide winter grazing for the dairy industry. Increasingly there is also competition for land use in Canterbury from high value vegetable seed and vegetable crops, especially potato. These vegetable seed crops are often high risk however some herbage seed crops are also viewed by growers as relatively high risk crops.

Herbage seed production in NZ focuses exclusively on temperate grasses and legumes, with perennial and annual ryegrass dominating grass seed production and white clover dominating legume seed production. Cultivars for amenity use (e.g. turf grass) are a small component of the NZ herbage seed production mix. New Zealand contributes only about 4% of the total herbage seed produced internationally, but is a significant producer and exporter of both perennial ryegrass and white clover (Table 1).

Rolston *et al*. (1990) reviewed trends in herbage seed production between 1980 and 1989, while Mather *et al*. (1996) and Clifford *et al*. (1996) reviewed aspects of white clover seed production in NZ and international marketing trends of white clover. This paper looks at the production trends in the NZ herbage seeds industry since 1990. It also looks at the challenges that face this industry and the opportunities that exist to add value in order to address these challenges.

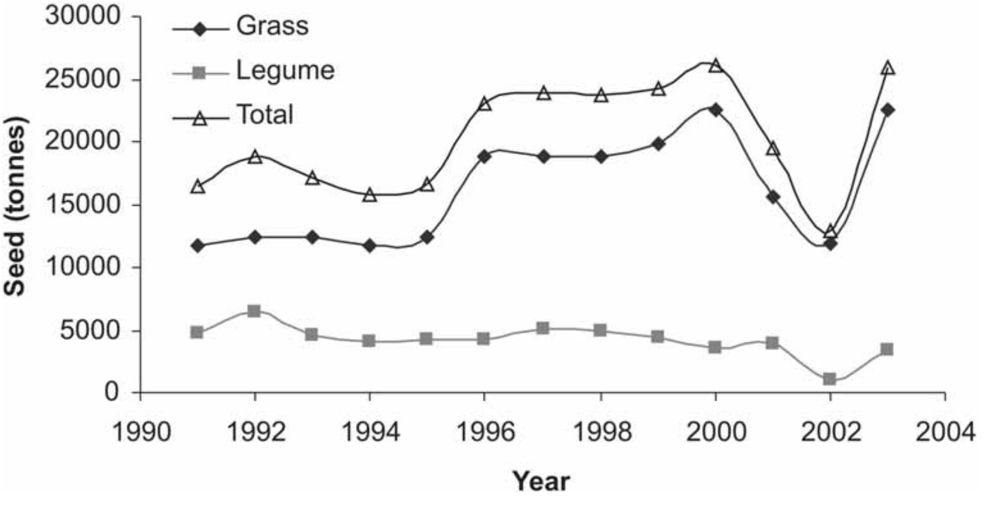
Annual seed production

During the past decade NZ has produced an average of 22000 t of herbage seed annually (Figure 1). These levels of production are slightly higher than the average of 20600 t produced between 1980 and 1989 (Rolston *et al*. 1990) but identical to the 50-year average reported by Rolston & Clifford (1989). Annual production has fluctuated from around 27000 t in 2000 and 2003 to as low as 14000 t in 2002. These major fluctuations in total seed production primarily reflect differences in the seasonal climate for seed production and, to a lesser

Table 1 International herbage seed production and NZ contribution in 2002 derived from Nas (2003).

Grasses	t ('000)	NZ%	Legumes	t ('000)	NZ%
Perennial ryegrass	203.2	6.7	Lucerne	98.0	<0.1
Italian ryegrass	152.4	4.4	Vetch	65.0	0
Tall fescue	84.2	0.8	Red clover	9.6	2.1
Other fescues	67.9	0	White clover	8.7	38.0
Cocksfoot	13.8	3.3	Other clovers	8.0	0
Poa pratensis	12.6	0			
Brome	7.4	5.6			
Timothy	8.9	<0.1			
Others	1.2	<0.1			
Total	**551.6**		**Total**	**189.3**	

Figure 1 New Zealand production of grass and legume seed (1991-2003) derived from AgriQuality Seed Certification Statistics.



extent, fluctuations in international supply and demand.

Domestic consumption is estimated to use about 33% of New Zealand's annual production to reseed on average 2% of sheep/beef pastures (160000 ha) and 5% dairy pasture (90000 ha) each year. Exports fluctuate, but in the 12 month period April 03 to March 04 ryegrass exports were 11530 t (38% being Nui) and white clover 1830 t (70% being Huia).

White clover seed production area has halved in the past decade, but overall white clover production has decreased at a much slower rate than expected from the decrease in area (Figure 1, 2). This is due to the better genetic potential for seed production of new proprietary NZ white clover cultivars (Widdup *et al*. 2004) and to better production methods (Clifford 1997).

The data reported in Table 1 from Nas (2003) are lower than previous estimates for white clover of over 10000 t (Mather *et al*. 1996) and may reflect the very poor seed production achieved in both NZ and Denmark in 2002.

The decrease in total production and the productive area of white clover in NZ has been associated with an increase in production in Denmark (Figure 2b). There has also been an increase in Australian white clover seed production with a significant production of Haifa white clover occurring in areas of western Victoria and South Australia under centre pivot irrigation. Regression equations derived from the data in Figure 2 show that total NZ white clover production is declining at 168 t/year ($r^2 = 0.37$); while cv. Huia is declining at 214 t/year (r^2=0.80). The increase in production of Haifa (Australia) and Nanouk (Denmark) has been in direct competition with Grasslands Huia seed produced in NZ. Huia, Nanouk and Haifa are commodity varieties that rely on their low cost to gain market share since they have inferior agronomic value. A good example of this is Huia. Released in 1953, Huia has been marketed in Europe for more than 50 years. Initially Huia was on the recommended list for most European countries due to its broad adaptation and agronomic performance; however,

Figure 2 Change in area for NZ (Huia and other) white clover (A) and NZ versus Danish total white clover seed production (B) and NZ ryegrass (Nui and other) (C) 1990-2003.

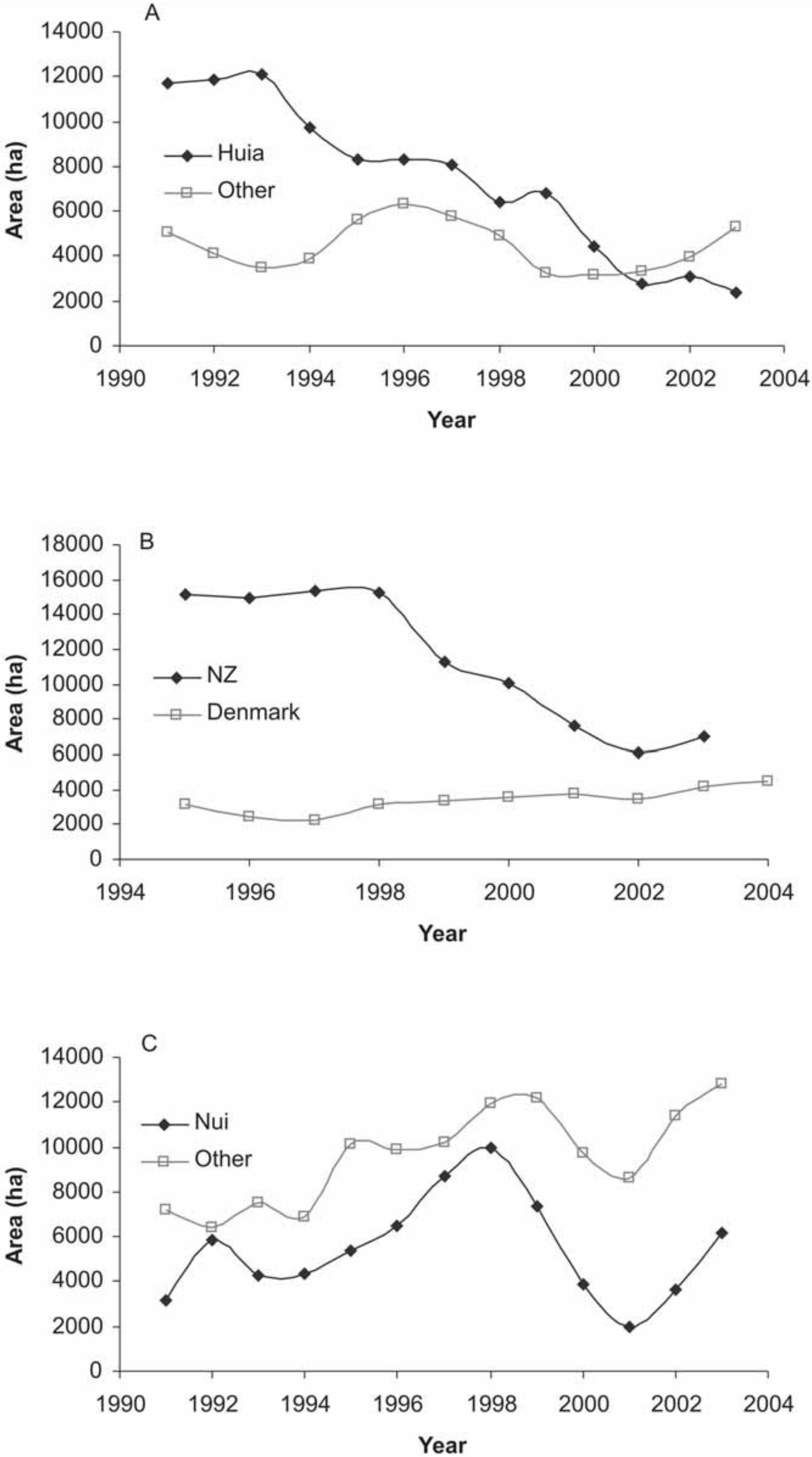


Table 2 Changes in public and NZ bred proprietary and overseas white clovers multiplied for re-export derived from AgriQuality Seed Certification Statistics.

	1991		2003	
	t	%	t	%
NZ public	3746	90	1438	43
NZ proprietary	51	1	1085	33
Overseas proprietary	376	9	794	24
Total	4173		3317	

in 2004 it is only on the recommended lists in Northern Ireland and Spain and even in these countries has been surpassed by better performing proprietary varieties (Gilliland 2004). Huia had a dominant position in the Northern Ireland market with 85% of the white clover seed sales in 1994 but this has now decreased to less than 50% in 2003 (T. Gilliland pers. comm.).

Production of grass seed in both Denmark and Oregon has fluctuated markedly but generally there has been an increase in the total tonnes produced. Production increases in Denmark and Oregon are not driven solely by the demand for seed. In Oregon the closure of vegetable processing plants in the Willamette Valley resulted in increased areas of grass seed being grown and in Denmark, the EU subsidies for seed production are often a key driver for producers.

There have also been significant shifts in the types of ryegrass produced in NZ. In 1999 perennial ryegrass equated to 71% of the total ryegrass production whereas in 2003 perennial ryegrass accounted for only 50% of the total ryegrass production. This shift reflects the increased demand for Italian and hybrid ryegrasses for animal production, particularly from the dairy industry in NZ and pastoral systems in Australia (Lambert 2002).

Proprietary seed production

There has been a major shift during the past decade towards the production of proprietary cultivars and we believe that this trend is likely to continue. In 1987 proprietary white clover cultivars accounted for only 7% of the total production, however, they now account for over 50% of the production. This trend has been driven firstly by the introduction of Plant Variety Rights (PVR) in NZ and the increase in private plant breeding activity and secondly by increased demand for these proprietary cultivars due to their superior performance in farming systems. The introduction of PVR has allowed cultivars to be developed that specifically target the requirements of individual markets and farming systems. This has included cultivars targeted for specific environments such as hill country and uses based on leaf size and stolon density. Widdup *et al*. (2004) has shown that selection for increased seed yield potential was effective in six New Zealand-bred white clover varieties. Improvements in seed yield were achieved irrespective of the leaf size or end-use of these cultivars, with improved seed yield observed in cultivars ranging from small-leaved cultivars, developed for intensive sheep-grazed systems, through to large-leaved cultivars for dairy systems.

The favourable white clover seed production climate in Canterbury and the technical expertise of our seed producers, in comparison to many overseas regions, has led to significant pressure on white clover area from overseas cultivars multiplied here (Figure 2, Table 2). Since this practice began in 1985 (Mather *et al*. 1996) the number of overseas cultivars has increased to 36 in the 2003/2004 season (AgriQuality 2003). This seed is predominantly grown for export to Europe and has been driven by the excellent seed quality that arises from the expertise of NZ growers and the stringent certification standards that are in place.

There has been a significant increase in the production of proprietary perennial ryegrass cultivars in the past 5 years, having increased from 37% of production in 1999 to 57% of the production in 2003 (Table 3). There has also been a significant lift in proprietary hybrid ryegrass production from 82% in 1999 to 98% in 2003 (Table 3). However, there has been only a small shift in the percentage seed production from public to proprietary Italian ryegrass in the same period; but the tonnage of proprietary cultivars have increased significantly (Table 3). The introduction of novel endophytes, in particular AR1 in perennial ryegrass has certainly played a role in the increase in proprietary perennial ryegrass seed production. The production of AR1 infected ryegrass has increased from 0 t in 2000 to 699 t in 2002 and to 1777 t in 2003. This means that AR1 endophyte is present in 21% of all forage proprietary perennial and hybrid ryegrass seed produced in 2003.

The other main shift among proprietary cultivars has been the development of cultivars with a much wider spread of flowering dates. This has had a significant impact on forage production but can also affect seed production since it provides farmers with greater flexibility around closing dates and flowering dates to reduce environmental pressures on seed production.

Table 3 Changes in ryegrass production (t) from 1999 to 2004 in forage proprietary and public cultivars compared with turf for hybrid, Italian and perennial (PRG) species and % production in each type.

Year	Species	Forage proprietary	Forage public	Turf	Total	Proprietary (%)
1999	Hybrid	1750	390	0	2140	82
	Italian	2140	970	0	3110	69
	PRG	4050	8550	890	13490	37
	Total	7940	9910	890	18740	
	%	42	52	5		
2003	Hybrid	3620	70	0	3690	98
	Italian	4840	1910	0	6760	72
	PRG	4590	4490	1180	10260	57
	Total	13050	6470	1180	20710	
	%	63	31	6		

Seed quality

More than 95% of New Zealand seed production is certified. Seed certification is essential in the production of high quality seed and certification standards to maintain both genetic and physical purity require isolation distances, known paddock history to meet set standards, paddock inspection, limits on the number of years crops can be grown for seed, and seed quality testing (Clifford *et al.* 1996). For white clover crops a five year interval without clover is required to change cultivars (Clifford *et al.* 1996). New paddocks must have low buried seed counts and pass paddock inspections for volunteers. This has required manual record keeping of paddock locations and paddock histories but new web based software Seed Crop Isolation Distance (SCID) (Johnson 2004) being developed by the industry, initially for the vegetable seed industry, is expected to revolutionise the tracking of paddocks and make the maintenance of isolation distances far simpler.

Challenges and future opportunities

The New Zealand herbage seed industry is well positioned to develop into a significant international provider of high value seed. Apart from the ongoing research challenges, the industry will need to consider and address issues around land use, water availability, rural infrastructure and the resource management act.

The future viability of the herbage seed industry must be built on increased profitability for seed producers particularly those producing clovers (Rolston 2003) or seed production will move to lower value land, as land use of more suitable land transfers to lower risk, higher profit activities.

Increased profitability can be delivered in several ways:

1. Removal of international subsidies that keep the international price of seed artificially low. Recent changes in the EU Common Agricultural Policy that uncouple direct payments from individual crops are an initial step towards this (Dabbert & Krimly 2004).
2. Increase the seed yield potential of herbage seed crops (Widdup *et al*. 2004; Woodfield *et al*. 2004; Barrett *et al*. 2004),
3. Improve crop management practices and harvesting technologies to increase the reliability of herbage seed crops, and improve the reliability of seed supply to international markets,
4. Introduce new technologies that will add value to seed produced in NZ and increase overall demand. Research that demonstrates the value to the end user of new technologies is an essential component in this process. A good example of this is the novel endophytes introduced into tall fescue and perennial ryegrass in recent years (Easton *et al*. 2001).

Projected climate change in Canterbury should increase the potential for seed production by providing a more predictable climate for production and harvest (Pyke *et al.* 1998). However, concurrent with this will be the requirement for more irrigation. Consistent production of high quality herbage seed, particularly if it contains added-value technology such as endophyte, will require irrigation at times of the year when demand for irrigation water is near its highest. The limited ground water resource within parts of Canterbury remains a threat to herbage seed production.

Research outcomes

Applied research on seed production in New Zealand is industry funded, with FAR being responsible for the investment of grower levy money in research projects. Research outcomes from these trials are delivered to herbage seed growers through FAR field days, seminars and regular mail-outs of Herbage Updates that summarise key research findings.

Recent seed production research findings are outlined below for ryegrass, fescue and clover.

Ryegrass

Significant increases have been achieved in perennial ryegrass based on research and technology transfer. In FAR funded trials the yield of the controls averaged 1200 kg/ha while the yield from the best treatments averaged 1990 kg/ha, a 64% increase in yield (Pyke 2003). Importantly, these results have led to significant gains for ryegrass seed producers. In 1994 very few growers achieved 2000 kg/ha seed yields (Rolston 1995), while in 2002/2003 season a survey of 23 crops in South Canterbury found 52% of growers exceeded 2000 kg/ha; and throughout Canterbury a few growers exceeded 3000 kg/ha.

The single largest, and most predictable, yield increase in ryegrass crops has been from the use of the plant growth regulator (PGR) trinexapac-ethyl (Moddus). Seed yield increases have been observed as the rate of Moddus increases and differences in response have also been identified between cultivars, seasons and locations (FAR Arable Update Herbage 2003). Yield responses have ranged from -12% to +154%, with an average yield increase over thirteen trials of 50% (Pyke 2003). This yield increase was less in non-irrigated crops and in crops where there were interactions of Moddus with other inputs. Yield increases in annual ryegrass were high (over 75%) while the use of PGR's in turf ryegrass resulted in smaller seed yield increases from a high base to yields of over 3000 kg/ha.

Yield responses from using fungicides are considerably less than from using PGR's. The yield increase was higher in turf types (40%), which are more susceptible to stem rust, than the forage types (20%). The increase in yield was very variable from year to year depending on the disease severity and cultivar susceptibility. The increase in yield ranged from a low 1.8% to 72%. Pro-active protectant fungicide programmes, using combinations of triazole and strobilurin chemistry, gave larger yield increases than programmes where chemical applications were targeted as curative and protectants.

Responses to herbicides in perennial ryegrass are very dependent on the weed species present. Large yield responses occurred when canopy competitive weeds such as wild oats were controlled (313%) but yield losses from competition with *Poa annua* can also be significant (Rolston & Archie 1999). Average yield increases from the control of Poa were 65% with the level of increase ranging from 6 to 205%. In addition to the increase in yield, seed quality was markedly improved as a result of removing Poa seed impurities.

Moisture stress can severely limit seed yield in perennial ryegrass. The duration and timing of stress had a marked influence on the yield. Stressing plants for approximately 6 weeks from mid stem elongation had less impact on seed yield than when plants were stressed for 6 weeks from early flowering. Yield increases of 350 to 500% have been recorded between severely stressed and fully irrigated plots.

The application of nitrogen (N) in soils with very low available N can provide yield increases of up to 600%. Even in soils where N is not severely limiting, yields have doubled through the application of nitrogen. Yield increases of 25% are common, however, the best gross margins have been from application of in the order of 50kg N in the autumn, 50 kg N in the late winter and 100 to 150kg N in the spring. These application rates resulted in the best water use efficiency and best nitrogen yield efficiency (Cookson 1999; Cookson *et al*. 1999)). Nitrogen rates and timing of nitrogen is becoming an increasingly important environmental issue in Canterbury for both the livestock and arable industry. The Proposed Canterbury Natural Resources Regional Plan Chapter 4 addresses the issues of nitrogen in relation to water quality and in the future seed growers may face restrictions on nitrogen use.

Fescue

Significant yield increases in forage fescue are relatively common in FAR trials but the magnitude of the yield increases is generally no-where near the same as from the same inputs in ryegrass. The average yield of the controls in these experiments was 784 kg/ha with the average best yield from the treatments of 1053 kg/ha, a 34% increase in yield.

Generally seed yield increases have been observed as the rate of Moddus increases with differences in the response between cultivars, seasons and locations. In trials the percentage yield ranges from –5% to 138% (Rolston *et al*. 2003). The average yield increase in eight trials, over 4 years, at number of sites was slightly less than in ryegrass at 46%. Growers generally report that yield increases in turf fescues have been very slight but the use of PGR's has resulted in improved ease of harvest.

A detailed trial on the use of fungicides in fescue exhibited a yield response of up to 18%, even though no stem rust infection was detected at any time during the growing season. In this research the fungicides increased the green leaf area.

Herbicides provide effective weed control in ryegrass crops, however, in fescue crops their use has resulted in crop damage and in losses in seed yield.

Limited research on N responses in fescue crops has shown good seed yield increases with autumn applied N. The yield increases varied between cultivars and ranged from 11 to 60%.

White clover

Yield responses to treatments in clover are not common. Most of the treatments that have resulted in increases in yield have been treatments that have reduced the vegetative growth prior to and during flowering. Some input treatments, weed and pest control, have also resulted in increases in yield. The average yield of the controls in FAR funded experiments was 445 kg/ha with the average best yield from the treatments of 618 kg/ha, a 38% increase in yield (Pyke 2003).

Large, 200%, increases in yield have resulted from the control of weeds using clover selective herbicides. The mean increase in yield from 9 herbicide trials was 52% (Pyke 2003). However, many herbicides tested influenced crop yield and quality by controlling the weeds and also by significantly reducing the crop vigour. Using herbicides to control crop vigour has often resulted in increased yield and the timing, rate and cultivar of clover can have a significant influence on the response.

In most crops moisture stress results in yield reductions. However, in clover withholding water at key times to reduce crop vigour can increase yield by up to 120% (Clifford 1985; Martin 2002).

Controlling insect pests, such as potato mirid, using insecticides can result in yield increases of approximately 20% (Schroeder *et al*. 1996). Although pollination is known to be a potential limit on yield in white clover, very limited research has been conducted. Varroa mite represents a serious threat and opportunity to the white clover seed industry and its arrival in Canterbury could lead to significantly higher pollination costs in the short term. However, if bee populations' decrease and pollination and regeneration of clover in pasture areas are reduced there could be an increase in the demand for white clover seed.

Future research needs

The future viability of the NZ herbage seed industry requires identifiable added value traits associated with the seed. This value could be in the form of improved genetics, new traits introduced through genetic modification such as control of flowering, enhanced nutritional value, improved nutrient and water use efficiency, or the addition of endophyte, rhizobia, germination controllers, soil active microbia and biological or chemical novel pest management tools to seed. These value added seeds are significant shifts from our current position and require changes in industry perspectives, research capability and marketing to secure outcomes that benefit the NZ industry. Such actions, as the development of a "Smart seeds cluster" for Canterbury to foster rapid development and protection of these technologies may be required to optimise benefits.

Recent research has delivered significant yield increases and some of the techniques that have been widely adopted by seed growers have enabled them to remain financially competitive with other land use options. However, much of the research on inputs has developed in isolation of a sound understanding of plant physiology and stage of plant development. For example, the timing of PGR' application and rates of application that give optimum yield response are currently based on experience rather than an understanding of the physiological development of the plant. Improved management of inputs or activities to maximise seed yield in current crops will be achieved through a better understanding of plant physiology and, in particular, the relationships between vegetative and reproductive processes throughout the whole growth season. In addition there is a very limited understanding of the role and function of root systems in herbage seed production systems.

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