

Seed yield variation in a red clover breeding population

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Abstract

Variation in flower number and seed yield of 330 individuals from a breeding pool were assessed for seed yield. The average per plant seed yield was 32 g plant⁻¹. Per plant seed yield ranged from <10 g plant⁻¹ (7% of plants) to >60 g plant⁻¹ (4% of plants). Seed yield was independent of time of peak flowering. There was a positive correlation between seed yield and flower number; but flower number only explained 18% of the variation in seed yield. A sub-sample measured for corolla tube length showed no correlation between length and seed yield.

Introduction

New Zealand's herbage seed producers are discouraged from growing red clover because of low returns (associated with low seed yield), limiting local market supply and increasing price kg⁻¹ to end users. End users are therefore discouraged from sowing red clover because of the increase in seed costs and decrease demand. This has stalemated the industry and New Zealand has produced about 150 T seed year⁻¹ for the last 5 years (Anonymous, 2009). New cultivars, like 'Sensation', have only replaced older technology rather than increased the market. A significant increase in red clover seed yield ha⁻¹ would increase supply and bring cost to the end user down while still ensuring a suitable return to the producer. Recent work confirming the heritability of seed yield components, including inflorescences per plant, has increased the interest in seed yield specific screening (Herrmann *et al.*, 2006).

This paper reports the results from a red clover breeding programme that, for the first time, looked at both seed yield and agronomic qualities as selection criteria.

Materials and Methods

The trial was undertaken at Lincoln, Canterbury, New Zealand (43° 63'S, 172° 47'E, 11 m a.m.s.l.). On 15 April 2008 a diploid red clover breeding pool was sown in root trainers and in a glasshouse on 1 July 2008 seedlings were transferred in trays to a shade house to harden off. On 2 October 2008, 330 seedlings were transplanted in to the field (a deep Wakanui silt loam with good moisture holding capacity) at the AgResearch Lincoln Farm as single, spaced plants on 850 mm squares.

Natural populations of long-tongued bumblebees (*Bombus hortorum*) and introduced short-tongued bumblebees (*B. terrestris*) were present during flowering (late November – late

February). On 20 January 2009 a subsample of 29 plants were chosen at random and three newly opened inflorescences per plant were removed. Five florets from the bottom-most 2 rows were then measured from the tip of the standard petal to the base of the sepals. On 18 March 2009 plants were harvested by hand following an application of diquat dibromide desiccant. Harvested material was dried in a glasshouse and seed was extracted using a belt thresher and screen dresser.

Results

The average per plant seed yield was 32 g. Seed yield ranged from 1 g to 79 g with 22 plants having <9 g (7%) and 5 plants >70g (4%) and 68% of plants within 1 standard deviation (15.3 g) of the mean (Figure 1).

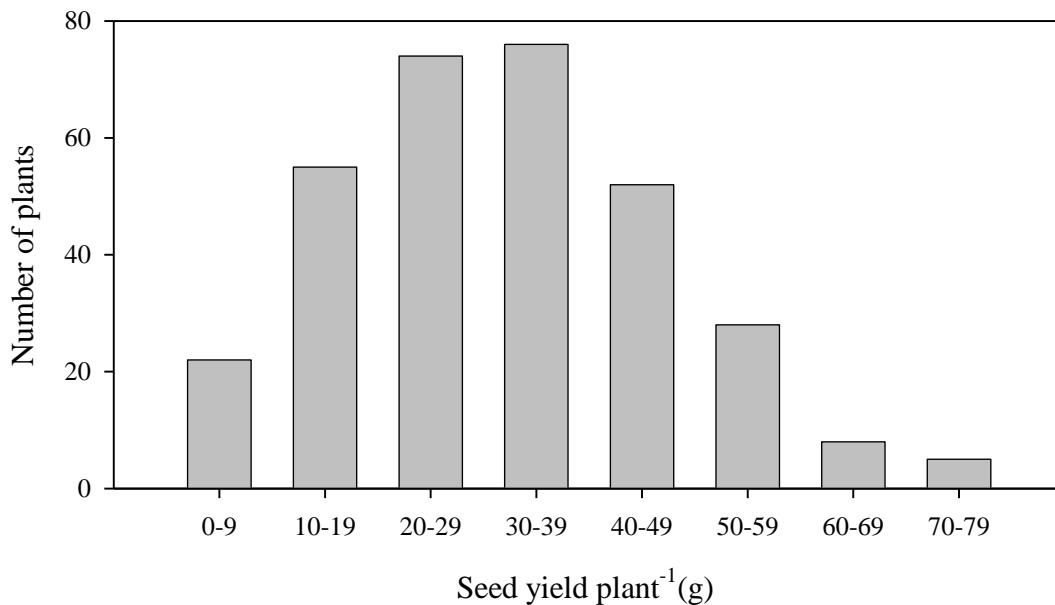


Figure 1 The number of plants within different seed yield bands

The average number of inflorescences at harvest was 465 per plant (Figure 2). Average number of inflorescences at harvest ranged from 128 to 976 with 67% within 1 standard deviation (215) of the mean. The seed yield per plant had a minor positive correlation ($R^2 = 0.09$) with number of inflorescences at harvest. There was a range of 32 days in the date of peak flowering. Seed yield was independent ($R^2 = 0.002$) of the time of peak flowering (maximum number of inflorescences with >50% of florets available for pollination) (Figure 3). All plants had reached peak flowering by 3 February 2009.

The average floret length on 20 January 2009 had a negative correlation to the number of inflorescences at harvest ($R^2 = 0.11$) (Figure 3). There was no correlation between average floret length and yield plant⁻¹ ($R^2 = 0.01$).

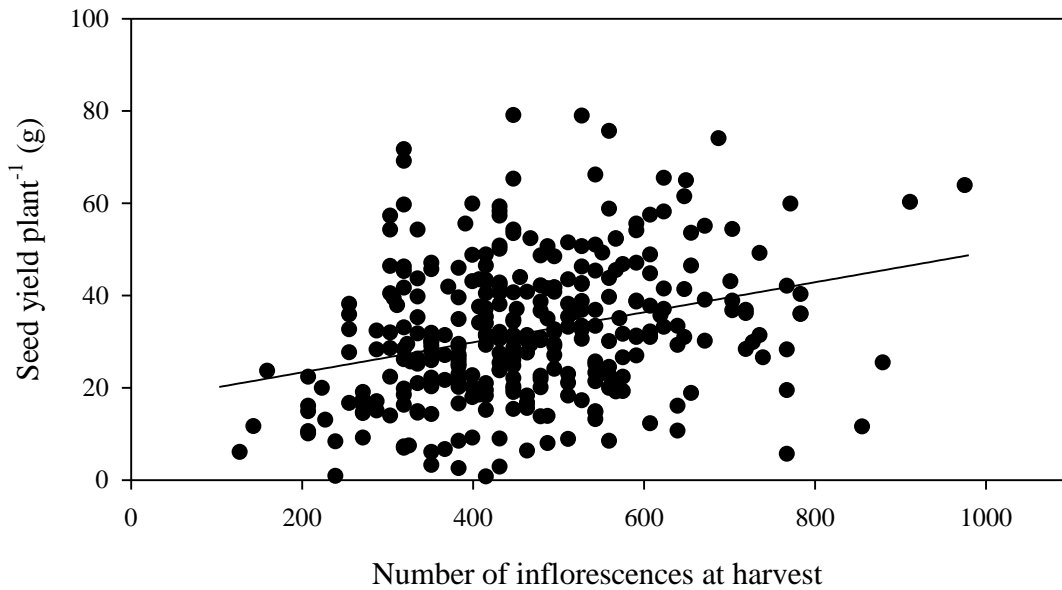


Figure 2 The seed yield per plant against the number of inflorescences at harvest

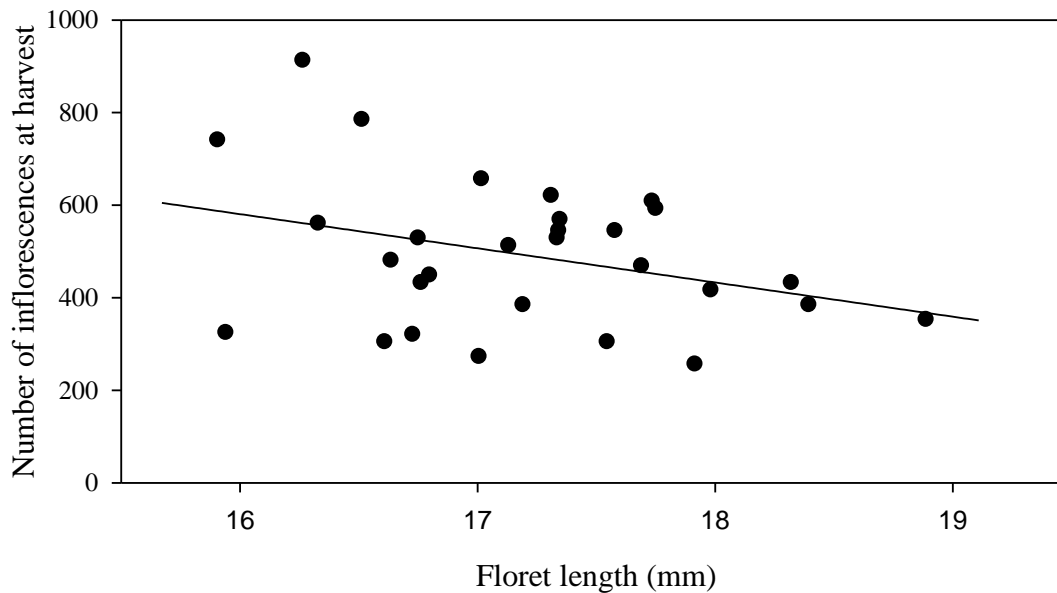


Figure 3 The number of inflorescences plant⁻¹ at harvest against the average length of 15 newly opened florets on 20 January 2009 for a subsample of 29 plants.

Discussion

A large difference in genetic potential for seed yield was identified (Figure 1 and Figure 2). Both seed yield and total inflorescence number varied in a breeding line nearing cultivar release status.

There may be potential to improve seed yield through selection of material from the positively skewed tail of the production curve. However, only 13 plants produced >60 g seed plant⁻¹ and screening for seed yield earlier in the breeding programme or screening larger numbers in a family structured population may result in greater advancement.

The best predictor of seed yield was the number of inflorescences (Figure 2), in agreement with past literature (Oliva *et al.*, 1994; Herrmann *et al.*, 2006). However, the length of florets and the date of peak flowering were not related to seed yield. The interaction between inflorescence number (Figure 3), pollinator type, pollination method (proper vs. side cut) and seed yield is not fully understood (Clifford and Scott, 1989). In both open and caged situations, the number of flowers successfully pollinated is variable (Rao *et al.*, 2007). Variation in pollinator visitation in red clover may result for multiple reasons including different levels of nectar, or colour, size and shape of the inflorescence and environmental and geographical conditions (Shuel, 1952; Brian, 1954; Marden, 1984). Further work with plant and pollinator interactions will lead to better management and increased red clover seed production.

Another consideration in selecting red clover plants for reproductive and agronomic performance from the spaced plant system is plant density and subsequent growth habit compared with production systems. In New Zealand, red clover seed producers typically sow diploid cultivars at 5-6 kg ha⁻¹ in 30 cm rows and plants stand erect, reaching 50 cm height with ease. Sown on 850 mm squares, New Zealand's grazing-type material typically lie prostrate or only semi-erect. The influence of this on successfully selecting material for pastoral applications is currently under investigation.

Conclusions

The experiment identified large differences in seed yield within a breeding pool of red clover and suggests that breeders could improve the seed yield potential of new cultivars by including seed yield as a breeding objective. There is also a need to better understand the interaction between plant spacing, selection and performance in a pastoral situation.

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Anonymous. 2009. Seed certification statistics 2008-2009. Palmerston North, New Zealand: AsureQuality New Zealand Ltd

Brian, A. D. 1954. The foraging of bumble bees. *Bee world*, **35**, 61-67.

Clifford, P. T. P. and Scott, D. 1989. Inflorescence, bumble bee, and climate interactions in seed crops of a tetraploid red clover (*Trifolium pratense* L.). *Journal of Applied Seed Production*, **7**, 38-45.

Herrmann, D., Boller, B., Studer, B., Widmer, F. and Kolliker, R. 2006. QTL analysis of seed yield components in red clover. *Theoretical and Applied Genetics*, **112**, 536-545.

- Marden, J. H. 1984. Remote perception of floral nectar by bumblebees. *Oecologia*, **64**, 232-240.
- Oliva, R. N., Steiner, J. J. and Young III, W. C. 1994. Red clover seed production: II. Plant water status on yield and yield components. *Crop Science*, **34**, 184-192.
- Rao, S., Stephen, W. P. and Bergh, J. E. 2007. Comparison of red clover pollination by commercial and native bees in seed production fields in the Willamette valley. *In*: W. C. Young III, (ed). Seed Production Research: Oregon State University Publication, **Vol. 127**, 59-61
- Shuel, R. W. 1952. Some factors affecting nectar secretion in red clover. *Plant Physiology*, **27**, 95-110.