**Key Points**

- There are opportunities for NZ to increase white clover seed production, but the difficulties in obtaining consistent yields means growers are choosing to grow more reliable crops instead.
- There is currently little information available to growers about the impacts of management on flower production and seed yield.
- Many of the flower heads harvested are already present within actively growing apical buds at the time of closing for seed production, and therefore some current management techniques may be reducing flower bud production.
- Seed development is maximised when flower heads are exposed to direct light at all stages of their growth, therefore understanding how to manage vegetative bulk is important.
- FAR & MAF SFF are funding a three project to understand and improve knowledge of crop growth and development.

**Background**

New Zealand (NZ) has long been dominant as a world producer and marketer of white clover seed. In 1996 NZ produced almost 50% (5,000MT) of the world’s clover seed. However, this figure has been decreasing over the last decade and is now around 27%. A major factor in this decline is that growers find it difficult to get consistent yields from white clover, and opt to grow other more reliable crops instead.

At present international clover seed production is threatened through changes in subsidies (Europe) and availability of water (Australia). If inconsistent yields could be overcome, there is a significant opportunity for NZ to reclaim its world market share, particularly of higher value proprietary cultivars. There is also increased demand for white clover seed in NZ for pasture renewal due to the impacts of varroa and clover root weevil, and the demands for high quality pasture for the dairy industry.

Currently there are no best management guidelines for clover seed crops (e.g. when to graze, how to manage leaf bulk, harvest management) and little information available to growers about the impacts of management on flower production and seed yield.

**Vegetative growth**

The main structural component of a plant is a stolon which consists of nodes and internodes. Each node produces one trifoliate leaf, a lateral bud and two nodal root buds. These root buds will grow if they come into contact with moist soil shortly after they emerge.

Branching occurs from lateral buds at the base of each leaf. At the growing tip of each stolon is the apical bud where leaves, lateral buds & flowers form. The more branches that form, the more growing tips there will be to produce further laterals, leaves and flowers. Branching is stimulated by light and the formation of nodal roots.
Shading from the canopy or from weeds combined with a lack of nodal root development reduces activation of lateral buds. Also, the further away lateral buds are from a root the less activation of lateral buds there will be.

Over time the older stolons die off in the center of the plant and the strong nodal root system supports the new tips, resulting in fragmentation of the plant.

**Nodal roots are important to encourage branching and flower formation:** How can we encourage nodal root development?

### Plant size

The size of a plant, leaves and flowers depends on the cultivar, the health of the plant and the time of year. If the apical bud is large it contains more cells and is capable of producing larger leaves and flower heads. There is also a seasonal change with apical bud size which means flowers get smaller and plants less vigorous as the season progresses.

**If harvest is delayed:** Do we end up only harvesting the smaller heads that were produced later on?

### Flower formation

The number of flowers produced depends on the number of active apical buds present. Flower buds are formed long before we see white flowers. The formation of buds is triggered by cold temperatures and long day length.

The time from flower head initiation to the appearance of the first white floret depends on the rate of leaf emergence from the apical bud. The rate depends on temperature. This is about 9 weeks when one leaf emerges a week and 4½ weeks when two leaves emerge a week.

**Flowers that we see in late November & December would have been formed in late September:** Could our management up until closing be removing potential flower buds?

Within each bud there can be up to seven developing leaves, but not all these leaves will have a flower head associated with it. This is because it takes more than the resources of one leaf to produce enough carbon to fill the seeds within a flower. Often there will be two or three leaves between flowers.

Abortion of flower heads occurs when the days are shorter and at low light intensity. Low light intensity is usually caused by the canopy shading the developing bud, or shading the healthy flower at the canopy surface.

**Flower buds were not initiated early on, or,**

**Flower buds were aborted because of canopy shading?**

### Seed production

Carbon is essential for flower head growth. In full light about half the flower heads’ carbon supply is provided by photosynthesis within the flower head itself. The remaining half comes from neighbouring leaves.

Canopy shade reduces both photosynthesis within a flower head and the amount of carbon imported from the leaves. Flower heads that are shaded have reduced photosynthesis, less carbon and therefore fewer seeds per head. There is also competition between flower heads and between ovules in a floret as they share a common pool of carbon.

**In a bulky crop:** Is seed production limited by shading, or the ability of bees to find and pollinate the flower heads?

### Pollination

White clover is self-incompatible and therefore relies on pollen from nearby plants for seed set. Insect pollinators are required for pollination as the pollen is not transported by wind due to the design of the floret. The honey bee is the major pollinator of white clover in NZ, with bumblebees and native bee species also contributing to a lesser extent.

The flower produces both pollen and nectar. Nectar, which attracts the bees, flows best at temperatures above 18°C. Many early flower heads may not get pollinated due to cool temperatures which reduce nectar flow & bee foraging. Pollen viability and nectar flow are reduced under more severe water stress, but some stress aids seed set by reducing vegetative bulk and this encourages bee foraging.

**FAR Research to date**

FAR has funded previous research on white clover focusing on weed and pest control, PGR’s, irrigation and bulk management. As with commercial trends, the success of a treatment in one season may not turn out to be the best treatment in the next season.

Some management techniques reduce growth and/or delay development. This may provide the plant with more opportunity to capture light and enhance flower formation, or delay the plant so that the flowering window is condensed, which allows us to capture more seed heads at harvest.

**Acknowledgements:** The information in this update came from presentations given at recent clover workshops by Rod Thomas, Bede McCloy, Nick Pyke & Tabitha Armour.