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BUMBLE BEE MANAGEMENT OPTIONS TO IMPROVE 'GRASSLANDS PAWERA' RED CLOVER SEED YIELDS

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Abstract

Three options of bumble bee management for red clover pollination are discussed: spring supplementation with queens caught outside the locality; colony introduction at flowering; and permanently sited hives close to the crop. The first two options must be carried out annually whereas the last option presupposes an adequate local food source prior to flowering. It is contended that even with successful permanent siting further annual introductions would be required where the area in crop is to be considerably increased. Details of hive construction, field placement and colony management are outlined. In 1982 the amount of seed set, on a machine dressed basis, for one colony of *B. hortorum* and *B. ruderatus* was 130 kg and 56 kg respectively

Keywords: Pawera red *clover,* seed yields, *Bombus hortorum, B. ruderatus,* hive construction, colony management.

INTRODUCTION

Three species of long-tongued bumble bees, *Bombus hortorum, B. ruderatus* and *B. subterraneus* were introduced to New Zealand about 100 years ago for red clover pollination. Under fine conditions long-tongued bumble bees are at least twice as efficient as honey bees on diploid clovers (Wojtowski 1965; Holm 1966; Bilinski 1977) and more numerous under suboptimal weather conditions (Wratt 1968; Macfarlane 1976). Although honey bees are fairly satisfactory pollinators of diploids (Palmer-Jones *et. al 1966)* they seem to be ineffective for the tetraploid 'Grasslands Pawera' (Clifford and Anderson 1980).

The mean national yield of Pawera seed is low at 51 kg/ha, a major reason being that fields over 5 ha are not adequately pollinated due to a "dilution" effect on the local bumble bee population (Clifford and Anderson 1980). In order to substantially enhance seed yields measures must be taken to promote increased populations of long-tongued bumble bees, There are three options which farmers can adopt:

1. In spring (mid Ott-late Nov), collection of over-wintered queens from other localities for release near the crop (Clifford 1973).
2. Bring in colonies from well beyond the crop. These can be purchased from a bombiculturalist or collected from natural sites.
3. Permanent placement of hives close to the crop for queens to nest in. For this method a suitable sequence of bee forage, either naturally occurring or planted, will be required to maintain seasonal continuity of bumble bee populations.

Although the first two options are essentially short term and labour intensive, they will prove necessary for a season when a large increase in crop area is contemplated.

Studies by Entomology Division have concentrated on; hive design, placement, and subsequent colony management followed by stocking of colonies on Pawera crops.

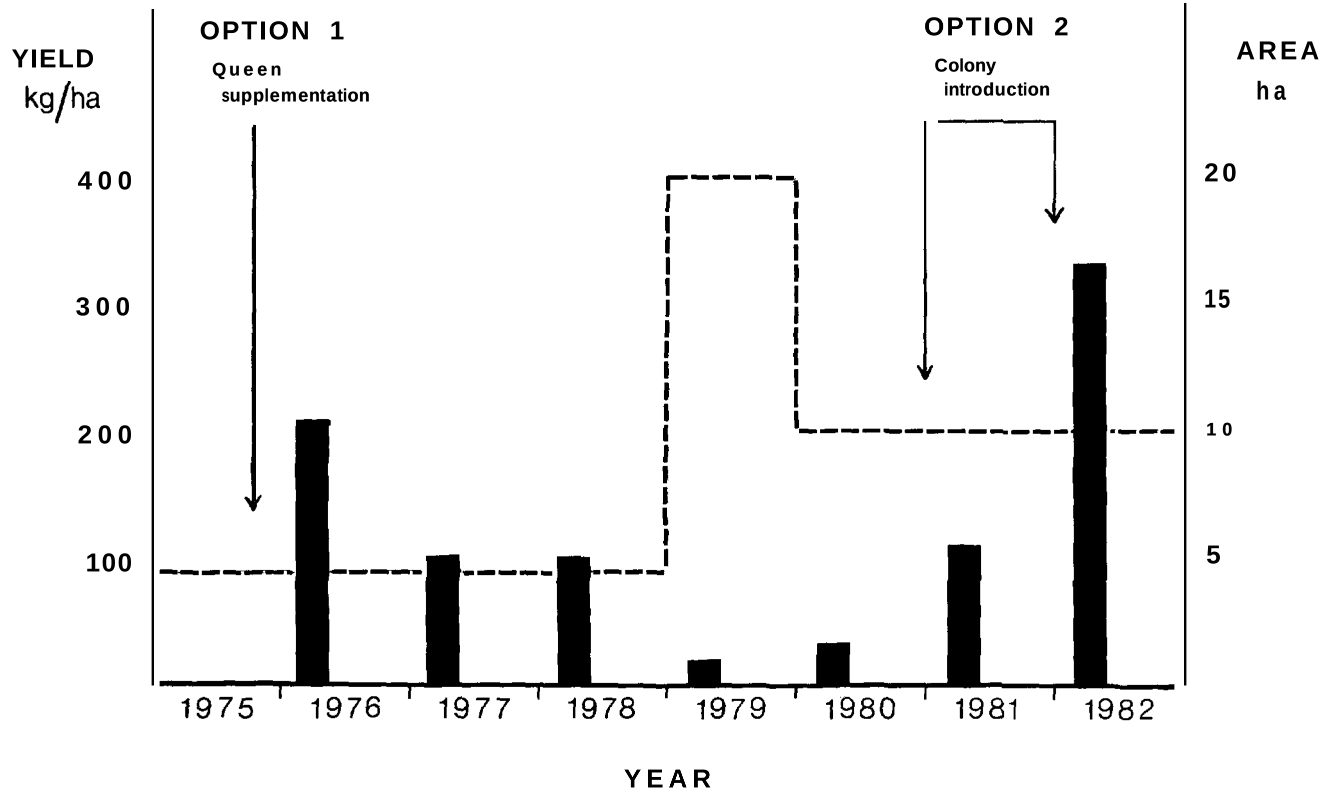

Fig 1: *Effect of queen supplementation and introduction of B. hortorum colonies in hives at flowering on increasing machine dressed seed yields of Pawera red clover near Geraldine.*

FIELD USE OF EXTRA BUMBLE BEES

Option 1: Queen Supplementation

Bumble bee queens were gathered from Geraldine in late October 1975 and released close to a 4.5 ha red clover crop on a farm some 9 km distant (Fig. 1). The seed yield (machine dressed) for the following harvest was 210 kg/ha. For the next two seasons no further queens were introduced, and the seed yield dropped to 100 kg/ha. Any influence these queens may have exerted on yield in 1976 was not carried through to the following season (see Clifford 1973). The major causes were:

1. insufficient hibernation sites,
2. insufficient food sources prior to red clover flowering,
3. insufficient nesting sites.

In the 1978/79 season there was a fourfold increase in crop area which resulted in a sharp reduction in seed yield to 17 kg/ha. The crop reached full flowering in March, which was too late to coincide with maximum colony size of long-tongued bumble bees. The following season, although the area in crop was halved there was no significant gain in seed yield. Another Pawera grower in the same locality obtained similar yields for those two seasons from a IO ha field. These results not only exhibit the effect of increased area on yield but also demonstrate seasonal fluctuations in bumble bee populations and highlight the need to co-ordinate full flowering with peak colony size.

Option 2: Colony Introduction

In the 1980/81 season 12 nests of *B. hortorum* were purchased from Christchurch and taken to the same farm described in option 1. Resultant seed yield more than tripled, to 110 kg/ha, and was equivalent to the yield from half that area when pollinated by the resident population (1977 and 1978 harvest years).

In the 1981/82 season 24 colonies (2.4/ha) were purchased from Christchurch and brought to the crop giving a threefold increase in yield (333 kg/ha). These colonies averaged 679 bees of which approximately 50% would have been actively working over the flowering period. Given that one bee can set to 0.6 kg of seed, and that 35% of seed can be lost at harvest and in dressing (Clifford pers. comm) the harvested seed yield potential from these colonies was 3100 kg i.e. similar to the result gained. In this case each colony produced 130 kg seed. This yield indicated there was little advantage from the 739 queens which emerged from the colonies introduced the previous season. A shortage of spring forage was considered to be the major limitation to any further increase in the local population. Consequently, in the spring of 1981 the farmer began planting a bee forage plot.

Option 3: Permanently Sited Hives

In 1982, a farmer near Blenheim sited 60 hives near his 3 ha crop. Within these hives 21 colonies of *B. ruderatus* developed. Some of the spring food source came from local gardens but most was from a crop of broad beans, followed by a strip of Pawera left to flower early (late December). Thus a sequence of food supply was provided to sustain the colonies, These averaged 290 bees of which about 50% were available for effective pollination of the crop. Using the same calculation as for the Geraldine crop, the total potential harvested seed yield from colonies was 1190 kg i.e. 395 kg/ha or 56 kg/colony. Actual harvested yield was 250 kg/ha or 145 kg/ha below that expected. For the most part this reduction in potential yield was a reflection of inclement weather conditions over the harvest period. Competition from flowering red clover crops on neighbouring farms may also have contributed. Even considering these factors the 250 kg/ha yield was still nearly three times the average (90 kg/ha) for the previous 4 seasons from a similar sized field, indicating a nett gain of 160 kg/ha from bumble bee management.

MANAGEMENT OF BUMBLE BEES

To capitalise on the improved seed yields gained from Options 2 and 3, some knowledge of hive construction, siting and resident colony management is necessary. For those wishing to follow Options 1 and 2, i.e., collecting queens and shifting colonies, Gurr (1972) provides an account on how queens can be transported and Alford (1975) gives guidance on how to collect and shift bee colonies. Persons wishing to use these techniques could also contact the authors for further advice.

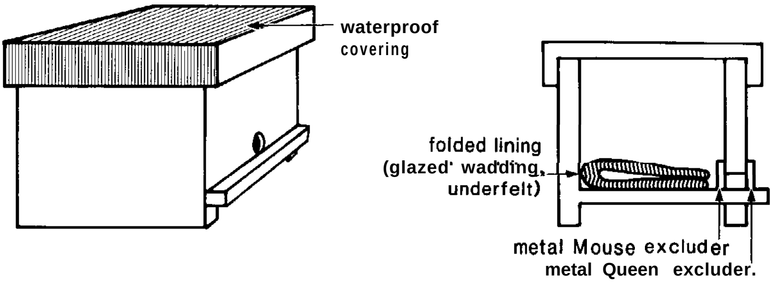

Fig *2: Standard wooden surface hive: 300 mm high, 290 mm long and wide externally; lid 75 mm deep; hive entrance 25 mm diameter, mouse excluder hole 11 mm diameter. queen excluder hole 7-8 mm diameter, wood treated 25 mm thick.*

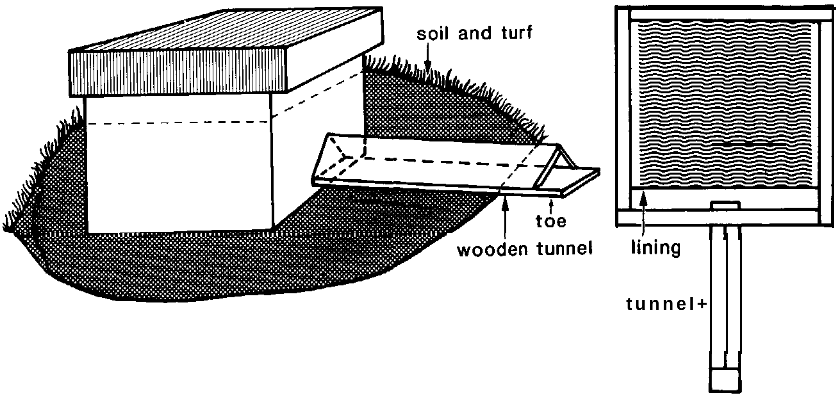

Fig *3: Wooden underground hive; dimension of hive and excluders as in Fig. 2, tunnel length 600 mm base, 500 mm on top, internally 40 mm high, 50 mm at base, tunnel timber 20-25 mm thick.*

Caution: A parasitic eelworm that sterilizes queens exists within a 40 km radius of Christchurch. Queens not producing nests by mid-spring have the highest levels of this parasite, but new queens in colonies could also be affected. Consequently, to avoid further spread of the parasite we advise that only colonies that have not reached the queen production phase can be shifted from the infected area and that queens collected in spring should not be taken from that area.

Hive Acquisition Option 2 and 3

There are three ways of obtaining hives. They can be purchased, hand-made (Figs 2 & 3) or acquired through the modification of other suitable containers e.g., nail boxes. After several years of testing hives, Entomology Division recommends two basic hive designs, a surface hive without a tunnel and an underground hive with a tunnel. B. *hortorum* will nest readily in hives without tunnels while *B. ruderatus* appears to have a slight preference for hives with tunnels. Two of the most effective and durable tunnel designs have a triangular or square cross section.

There are several essential points to consider when making hives. They must be waterproof; queens prefer to nest in a dry rather than moist or musty lining, hence the raised floor and a waterproof lid. The hive must be completely bumble bee proof to protect the foundress queen from invading queens during colony development and to ensure that no bees escape when shifting hived colonies. Care must therefore be taken that all joins fit well and knot holes are well sealed. Galvanized nails help maintain tight joins. Freshly treated timber should be weathered for several months prior to bee nesting. Lids must fit so they can be removed smoothly with minimal disturbance to the colony. Glazed wadding (used in upholstery) or underfelt make suitable lining material. Excluders to prevent entry of invading queens and mice can be cut from perforated steel plate or drilled from metal plate provided that the recommended aperture size is adhered to as even small deviations from this can cause problems. The mouse excluder is a permanent fixture to prevent mice from damaging the nest or the lining material.

Hive Placement

For permanently positioned hives placement should be as close as possible to the target crop but consideration should also be given to an adequate sequential food supply. This will encourage the colony to build up to peak strength for the red clover pollination in February. Gaps in this food supply disrupt the ability of the colonies to develop fully. Garden plants, hedges or crops most attractive are: black locusts, azaleas, fuchsias, honey suckles, russian comfrey, *Salvia* spp., delphiniums, russell lupins, flowering currants, apple blossoms *(Weigelia)*, escallonias, silver germander, citrus, raspberries, beans and pumpkins. Weeds of value are: foxgloves, blackberries and vipers bugloss.

The surface hives are the easiest to shift, but they should be fenced from livestock. Underground hives must be dug in and once established they can withstand considerable livestock abuse although damage can be caused from continual disturbance from hens, pigs and cattle. The terrain should be well drained and free from excessive wind, shade or heat. The vegetation cover may range from short to long or dense grass. A site against a tree, building, rock, tree stump or fence aids bee orientation. Least successful hives are those sited under pine trees or those with entrances facing south.

Annual Routine for Colony Management

New hives should be installed in the field in autumn or winter, mainly to allow time for the turf to become firmly established around the underground hives by mid-spring. Hive entrances should be cleared and unserviceable lining material renewed by mid-September. The main nesting period for *B. hortorum* is late September to late November and for *B. ruderatus* is late October to mid-December.

When founding a nest the queen lays 8-14 eggs, then feeds and incubates the brood which will hatch as workers 20-25 days later. Hives should be checked for nest development 4-6 times at 15 day intervals during the main nesting period. A queen excluder must be applied promptly after the first 6-10 workers emerge to prevent "pirate" queens from fighting with the foundress queen. Up to 30 valuable queens in a single hive have been found dead through fighting for nest possession. As a result, colony development is often adversely affected. Queen excluders must be removed from medium sized nests 3-4 weeks after application so that new queens produced can forage.

A colony remains at peak foraging strength for 3-5 weeks after queen production.

Occupation and Future Developments

Under good management hive occupation in favourable sites from season to season is consistently 30-60% in permanently sited hives. A better understanding of hibernation requirements and improved knowledge of the natural food supply should enhance these present levels.

One aspect of the continuing research programme which is showing considerable promise is the use of a bee feeder. This consists of a mixture of honey, icing sugar and pollen, packed into a plastic bottle top e.g. from a flagon, and then covered with gauze nylon with a 1-2 mm mesh. Using this feeder may improve average colony size and increase the efficiency of management.

CONCLUSIONS

Higher yields have followed the presence of larger numbers of pollinating bees but exact quantification of these is difficult. From the results presented it would appear that a colony of *B. hortorum* is worth 130 kg of machine dressed seed while one of *B. ruderatus* may give 56 kg. With the exception of Option 3 which inferred an adequate food source up to crop flowering, supplementation by way of queens or colonies will need to be carried out each season. This could also be required in Option 3 should a large increase in crop area be envisaged. Where an acceptable level of management cannot be practised on the farm, the alternative of purchasing colonies raised in areas of abundant spring food source has a promising future. This was indicated by purchases over the last two seasons at $15-$20/colony. If colonies cost $20 each and the farmer receives $5/kg for seed then a nett profit of $630 and $260/colony for *B. hortorum* and *B. ruderatus* respectively is possible.

From this evidence coupled with our continuing research programme to further improve bumble bee management, we foresee a marked improvement in seed yields from consistent growers who utilise this knowledge.

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