Losses of bees during mowing of flowering fields

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From the point of view of bee keeping flowering meadows should be mowed after withering. In animal farming, however, it is often necessary to mow at an earlier date. In this case, our recommendations should be observed in order to avoid bee losses.

INTRODUCTION

Honey bees and other insects visiting flowers need meadows with a high amount of flowering herbs for their supply of pollen and nectar. Hence, great numbers of bees are present in these fields during flowering. Occasionally, flowering dandelion or white clover meadows are mowed although a great number of bees are foraging. Rotary mowers, frequently combined with a processor are commonly used. They break and crush the mowed grass in order to accelerate the drying process in the field.

Bee keepers fear considerable losses of bees due to this kind of mowing. Little information about bee losses due to mowing machines is available yet in the international technical press. The aim of the present study was to clarify the extent of bee losses caused by mowing of flowering fields and to indicate how bee injuries and losses can be avoided.

TRIALS

Plots, mowing process

Three trials on level plots of the trial farm in the Research Station Tänikon (between Winterthur and Wil) were carried out from 1996 to 1999. One pure phacelia field was cultivated in 1996, two meadows with over 50 % of white clover were cultivated in 1998 and in 1999 (fig.1, 2). Each plot measured approximately 1/3 hectare.

Fig. 1. Flowers of phacelia.

Five or six bee colonies were placed along one side of the plot a few days before mowing. They were weighed daily in the morning and in the evening, beginning two days before the trial until the day after.

Fig. 2. Counting window, measuring 2 x 2 m, in the white clover field

The following trial conditions had to be complied with :

- Good development of flowers in the culture
- Morning temperature above 16 ^{o}C, sunny, at the most slightly windy
- Lively foraging bees in the culture

A drum mower (width 1.8 m) with integrated processor fixed at the side of a tractor was used for mowing (fig.3, 4). It breaks and crushes the grass before dropping it in rows behind the mowing machine. The processor was adjusted to the usual high processing standard. In order to compare the effect of the processor mowing was also done without processor in the 1999 trial.

Fig. 3. Tractor with mower fixed at the side, mowing the white clover field

Two variants of speed were chosen: 6 - 8 km/ h (normal in practice) and approximately 2 km/ h (slow). The plots were mowed lengthways. About two thirds to four fifths of the field were mowed on the day of trial.

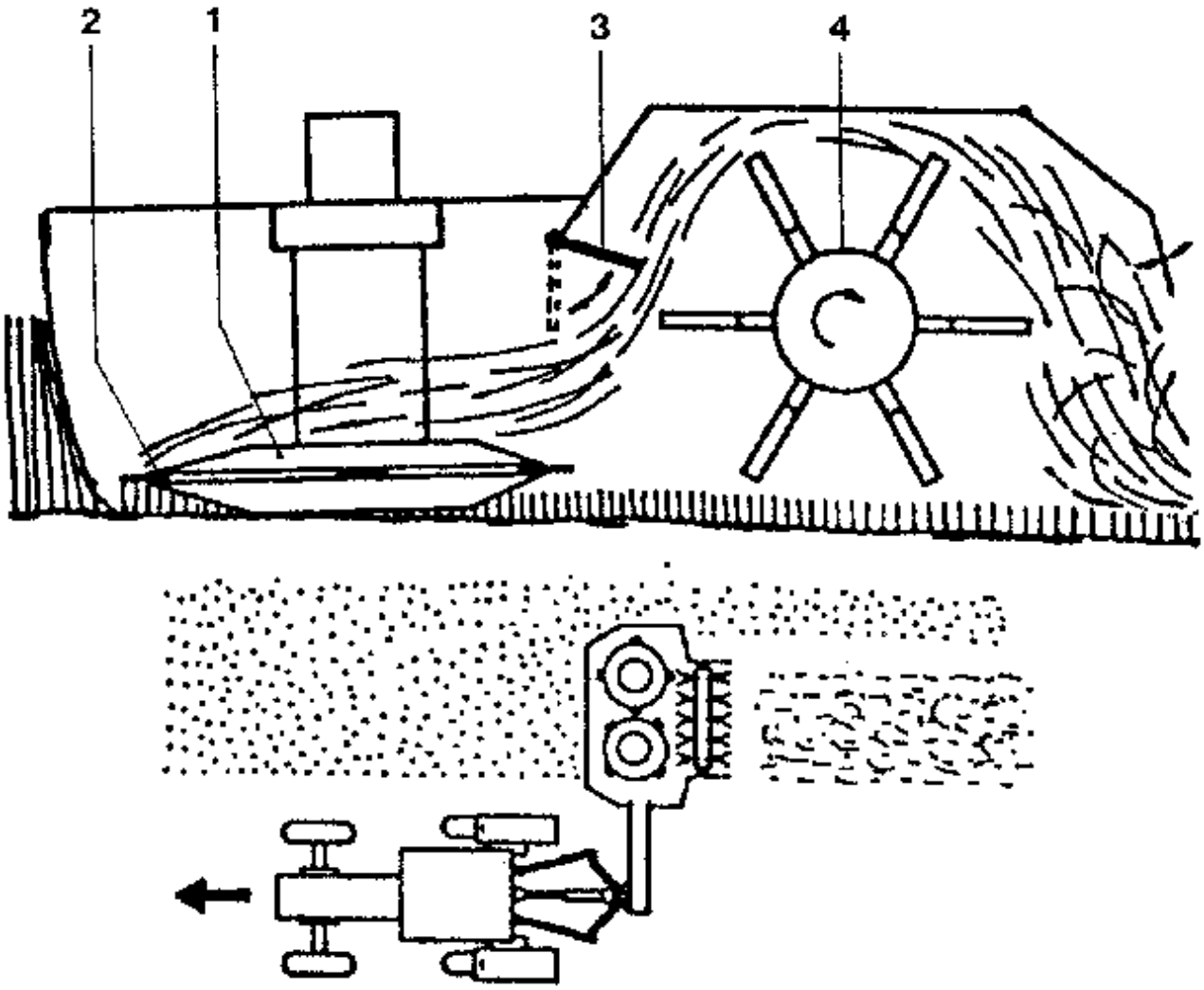

Fig. 4. Above: cross section diagram of rotary mower with processor. 1 = mowing drum. 3 = processor comb (adjustable). 2 = mowing blades. 4 = Rotor with rigid tines.
Below: Diagram showing a tractor with mower fixed at the side

Calculation of bee losses

The number of bees in the field immediately before mowing as well as the number and the condition of bees in the mowed grass were recorded in order to determine the losses of bees. The bees in the field were counted in spot checks by means of counting windows of 1 to 4 m^2 surface which had been marked in advance (fig. 2). Bees were counted in random samples in the mowed

grass immediately after each passage of mowing (fig. 5, 6). The calculation of average bee losses per m^2 respectively per hectare (ha) was based on these numbers. Honey bees were differentiated from bumble-bees. No further wild bees were noticed. The condition of bees was recorded according to following categories:

Fig. 5. Picking up a measured sample of mowed white clover, immediately after the passage of the machine

- Bees able to fly (not injured and injured)
- Bees unable to fly (injured, but viable)
- Dead bees

Fig. 6. Picking out and counting bees in sample of mowed white clover

Observation of behaviour

The behaviour of bees was observed from the moment the mowing machine approached and the flowers with bees got into the rotary mower. Observations were carried out on the moving mowing machine (fig.7).

Fig. 7. Observing the flight behaviour of bees, when the mowing machine is approaching. The flowers of phacelia are situated in the height of the upper machine cover.

RESULTS

Bee losses

In the **phacelia field** the average number of bees on the day of trial was 26/m^2 or 260‘000 bees/ha. About 9 bees/m^2 or 90‘000 bees/ha or 35 % of the bees present in the field were counted in the mowed grass (see table). All three categories of bees (able to fly, unable to fly but alive and dead) are included in these numbers. Most bees that were able to fly had visible injuries of abdomen or legs. Their survival was as unlikely as that of bees unable to fly. The slow or rapid speed of the mowing machine had no significant effect on bee losses.

	Phacelia 27.6.96	White clover 10.7.98	White clover 16.7.99
A Before mowing Number of bees in the field [animals per ha]	260‘000	17‘000	39‘000
B After mowing with processor Number of bees in the mowed grass [animals per ha]	90'000	9'000	24'000
[% of A]	35	53	62

Table. Bee losses during the three trials carried out

In the phacelia trial an average of 170‘000 bees/ha or 65 % of the bees present in the field escaped the mowing machine. These were foraging on flowers higher than the upper edge of the

mowing machine (about 70 cm above ground). They were shaken off onto the horizontal cover of the machine. From there they managed to fly away (fig. 7).

An average of about 2‘000 bumble-bees were present in one hectare of the phacelia field. Practically none of these were found in the mowed grass.

On average 1,7 bees/m^2 or 17‘000 /ha were present in the **white clover fields** on July 10, 1998 and about 3,9 bees/m^2 or 39‘000/ha on July 16, 1999. After mowing with a processor 0,9 bees/m^2 or 9‘000 bees/ha (1998) respectively 2,4 bees/m^2 or 24‘000 bees/ha (1999) were found in the mowed grass (table). Hence, about 53 % of the bees present in the field re-appeared in the mowed grass in 1998 and 62 % in 1999.

Comparison with and without processor

The difference found between the passages of mowing with or without processor in the white clover field was highly significant concerning the bees counted in the mowed grass: with processor an average of 14‘000 bees/ha re-appeared unable to fly or dead and without processor an average of 2‘000 bees/ha (fig. 8). In the variant with processor seven times more bees were lost than without processor.

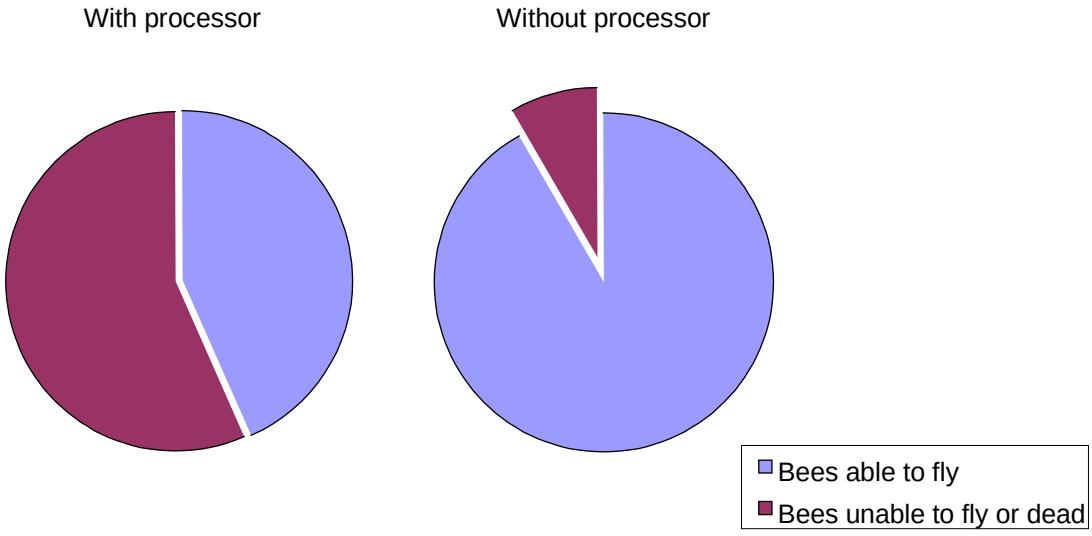

Fig. 8. Effect of mowing without, respectively with processor, on the degree of injured bees in mowed grass.

The functioning of the mowing processor explains this great difference. Without processor the mowed grass passes the mower without further mechanical treatment, and the plants are placed gently and uniformly in a row, the flowers facing upwards (fig. 9). Most bees foraging on the plants passed the mower unhurt. Many bees flew away after the machine had passed, while others were undisturbed and continued foraging on the flowers in the row.

Fig. 9. Varying appearance of mowed grass: in front: grass mowed without processor, the plants are put down gently, the flowers are facing upwards; behind: grass mowed with processor, the plants are broken and jumbled up.

Types of injuries

Bees found in the mowed grass that had passed the processor showed the following external injuries (fig. 10):

Abdomen crushed, deformed or torn open, discharge of haemolymphe

Abdomen with erected sting and venom bladder

Abdomen, thorax or head severed

Legs or wings immovable or partly severed

Fig. 10. Typical injuries of bees in the mowed grass, mostly caused by the processor.*Top:* bee, crushed, unable to fly. C*entre, from left to right:* bee without abdomen, abdomen alone, thorax alone. B*ottom:* bee without hind legs, bee without head

Several bees showed no obvious external injuries , but were unable to fly. Supposedly they had internal injuries. On the other hand, several bees were able to fly away despite of their visible

external injuries, e.g. erected sting apparatus, deformed abdomen. But they could not conceivably continue living as worker bees in a colony.

Behaviour of bees in front of the mower

Foraging bees reacted in no way to the loud noise and the vibrations of the passing tractor and the nearing mowing machine. Bees continued foraging undisturbed even in front of the mower. Several bees started reacting only, when the plants were dragged and tossed by the machine. Others clung on to the flowers even during this fraction of a second. The height of the flowers compared to that of the mower determines how many bees pass through the machine. The upper cover of the mower used in this trial was 70 cm above ground. Bees foraging on flowers below this height had practically no chance to escape the machine. No substantial difference in the behaviour of escaping bees could be found between slow and rapid speed. Bumble-bees showed a clearly faster escape reaction compared to the sluggish behaviour of honey bees, and they often succeeded in flying away.

Changes of weight of bee colonies

The weight of five colonies along the phacelia field increased and decreased daily by up to 900 grams. However, the fluctuations occurred so irregularly that no clear conclusions can be drawn. Strikingly, none of the five colonies showed an increase in weight on the day of trial, however, the weight of four colonies decreased by 300 to 600 grams. This might be explained by a loss of bees during mowing of the phacelia field.

DISCUSSION

Bee losses

The trials indicate the possibility of considerable bee losses, when flowering fields are mowed with mowing processors. The extent of losses depends mainly on the culture (attractiveness for bees, height of flowers above ground), on the intensity of foraging and on the mower (with or without processor).

The different height of the cultures might explain the fact that the rate of bee losses of 53% and 62% in white clover fields exceeded distinctly those of 35% in the phacelia trial. The white clover flowers were about 25 to 30 cm above ground, therefore the bees' chances to escape the mower was minimal. In phacelia fields, however, most flowers were taller than the mower and the chances of escaping were much better.

On the other hand, the bee losses of 90'000/ha in phacelia fields exceeded those of 9'000/ha and 24'000/ha in white clover fields by a factor of four to ten. This difference can be explained by the

intensity of bees foraging: in phacelia fields there were seven to fifteen times more foraging bees than in white clover fields.

Impact on bee colonies

Bee colonies along the fields were not weakened substantially by the mowing trials. However, no exact record of bees leaving and entering the hives was kept. It may be assumed that bees foraging in the trial fields came from several further hives. Thus, bee losses were spread among a larger number of bee colonies. Nevertheless, the impact on one single colony should not be underestimated. In summer average bee colonies contain about 25'000 to 30'000 worker bees. About one third of these are foraging bees. If suddenly a major part of foraging bees is lost due to mowing, this may temporarily lead to losses in the foraging yield and to irregular colony development. Healthy bee colonies are able to compensate losses of one age group within several days or within a few weeks.

No wild bees were found and recorded in our trials, with the exception of bumble-bees. Their incidence in the fields was mostly below 1% of the number of honey bees. Even less bumble-bees were found among the injured or dead insects. Their faster escape reaction (compared to bees), when the mower approaches, might explain this.

Cultures

In agricultural practice phacelia is mainly cultured for green manure. Generally, it is mowed or battered before flowering, in order to prevent seeding. White clover meadows are occasionally mowed at the time of flowering, especially in summer. In spring, dandelion meadows are occasionally mowed during flowering. Bee losses similar to those in white clover can be expected, if the mowing is done while bees are foraging intensely.

The effect of battering on insects visiting the flowers may differ from that of mowing with a processor. According to a German study battering of a phacelia field caused no serious bee losses. In this case the tractor drove in front of the battering machine presumably chasing away a part of the bees (Kalthoff et al. 1998).

Mower

The processor is the major cause for bee losses. Most of the bee injuries occur after cutting the plant stems, when the mowed grass is snapped and crushed in the processor. The bee injuries recorded can be explained by their treatment within the processor.

Apparently the speed of the tractor has no noticeable effect on bee losses.

A mower with suitable device rejecting bees is conceivable. But, first of all such device has to be developed.

RECOMMENDATIONS FOR PRACTICE

In order to keep losses of bees at a minimum, we recommend to:

- Observe the activity of bees in the hive immediately before mowing. Rule of thumb: if more than one bee per m^2 surface is present on the flowers, mowing resp. battering should be postponed until a time, when less bees are foraging.
- Consider the weather and the time of day: generally, less bees are foraging, when the sky is overcast, the temperature is low or a strong wind is blowing, and also early in the morning before about 7 a.m. or in the evening after 6 p.m.
- Use a suitable mower: rotary mower without processor or mower with cutter bar.

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SUMMARY

Meadows in agricultural areas often contain large numbers of plants whose flowers are visited by honey bees (Apis mellifera) and other insects for nectar and pollen. The mowing of such meadows with modern mowing machines was investigated to see if it leads to losses of bees. Two white clover fields and one phacelia field were mowed in June and July using a rotary mower with an integrated rotor processor in the presence of intensively foraging bees. The machine cuts and crushes the hay. Bees were counted on the field just before mowing and the number and the condition of bees present in the mowed hay were recorded. Before mowing there were between 1.7 and 3.9 bees per m^2 in the two white clover-fields and 26 bees per m^2 in the phacelia-field. Between 53 % and 62 % of the initial bees were found in white clover hay while 35 % were found in phacelia hay. About half of the bees found in the hay were dead or unable to fly. The other half were able to fly but most of them were injured. The chances that they could continue foraging were relatively low. About 9‘000 to 24‘000 bees per hectare were lost in white clover fields and 90‘000 bees were lost in phacelia fields. When the rotor processor was removed from the mower,

the number of dead bees or bees unable to fly in white clover hay decreased by 86 %. Many bees were observed, which flew out from the hay and continued foraging on the white clover. Recommendations for farmers, mowing flowering fields are given in order to keep bee losses as low as possible.

KEYWORDS: *honey bee, losses, mowing-machines, white clover, phacelia, bee protection, agriculture*