Compensation in spring sown oilseed rape after attack by pollen beetles (*Meligethes aeneus* F.)

*Kompensation i vårraps efter angreb af glimmerbøssen (*Meligethes aeneus *F.)*

JØRGEN AXELSEN og PER SEJERØ NIELSEN*)

Summary

The quantitative and qualitative changes occurring in spring sown rape, after an attack by pollen beetles (*Meligethes aeneus* F.) in the early bud stage, have been investigated in cage experiments. A reduction in mean size of seeds is the most serious change. The mechanism behind the compensation is discussed in relation to the presently rather varied view of the pollen beetle as a pest on oilseed rape.

Key words: *Meligethes aeneus, Brassica napus,* seed yield, compensation.

Resumé

De kvantitative og kvalitative ændringer, der forekommer i vårraps efter angreb af glimmerbøssen (*Meligethes aeneus* F.) i det tidlige knopstadium, er blevet undersøgt ved hjælp af burforsøg. Den alvorligste skadevirkning er en reduktion i den gennemsnitlige frøstørrelse. Rapsens kompensationsevne diskuteres i relation til glimmerbøssens skadevirkning.

Nøgleord: *Meligethes aeneus, Brassica napus,* frøudbytte, kompensation.

Introduction

The pollen beetle (*Meligethes aeneus* F.) is the most serious pest on spring sown rape (*Brassica napus* L.) in Denmark. The beetles arrive in the early bud stage and by chewing their way through the buds they cause abscission, leaving podless stalks. However, if the plants are stressed for some other reason, the same reaction may result, and consequently podless stalks have been observed on plants, from which pollen beetles were excluded (17, 18).

Several investigations in Sweden and the U.K. have demonstrated the remarkable power of compensation especially in winter rape, after attacks by pollen beetles or artificial injury to the buds (3, 13, 15, 18).

Considering other reasons for podless stalks and the power of compensation *Free* and *Williams*

*) Adress: Zoologisk Laboratorium, Universitetsparken, DK-8000 Århus C.

(3) suggest that the damage caused by pollen beetles is overestimated. In contrast, *Nilsson* (9) believes, that control measures are nearly always profitable.

In Denmark the actual economic threshold level is one beetle per plant in the early bud stage. It is to some extent bound by tradition and based on Swedish investigations, which is problematic because plant densities in Swedish rapefields are much higher than in Danish fields. Results from the U.K. can not be used uncritically either. The Danish growth season is slightly shorter, and the beetles do not start their egg-laying immediately after their arrival in the field, which is the case in England (4). In the following we present the quantitative and qualitative changes, occurring in spring sown rape in Denmark after an attack by pollen beetles in the early stage, as indicated by cage experiments.

Material and methods

The research area was an unsprayed part of a commonly managed rape field, located near Aarhus, eastern Jutland, Denmark. The crop (cv. Gulliver) had received 160 kg nitrogen per ha (artificial fertilizer and pig manure).

The experimental units were cages covering 1 m^2 each and with a height of 1 m. They were constructed according to the design of *Tulisalo et al.* (16), with finemesh synthetic net and poles of angle iron.

The cages were pitched, before the rape had reached the bud stage. The nets were removed on 28 June, when the rape began to bloom, in order to reduce the effect of the cages and to allow bee pollination. The physical effect of the cages was damped temperature oscillations, with day maximum 1°C lower and night minimum 1°C higher than in the surroundings. Temperatures were measured by thermographs placed right over the ground.

The pollen beetles were caught by sweep nets on dandelions (*Taraxacum vulgare* L.) in the first week of June in the Aarhus area. The beetles were stored at 6°C for a few days before being introduced into the cages. 100 beetles were checked for species composition; 2 *M. bidens* Bris. were found, the rest being *M. aeneus* F.

25 cages were pitched in a Latin square design. The plant stand in the cages was thinned out to 100 plants per cage. On 9 June, when the rape plants had reached growth stage 3.0–3.1 (8), beetles were introduced representing five different attack levels, viz. 0, 100, 200, 350 and 500 beetles/cage with five replicates. It was expected that all beetles etablished themselves in the cages.

The spring was cold and wet, and sowing time was 25 April with row distance 12 cm. A period of 3 weeks in June with sunny, dry weather, caused severe drought. Harvest time was normal, i.e. the last week of August.

The plants from the cages were harvested by hand and dried for about two weeks in the laboratory at room temperature.

A test sample of 25 randomly chosen plants was taken from each cage for detailed investigation. The number of side racemes, pods and podless stalks were counted. The oil content was determined by extraction by Aarhus Oil Factory Ltd. This measure, as well as the 1000-kernel weight were carried out on the total seed sample. The seeds were separated according to size, less/greater than 2.0 mm. The seed yield was only measured per cage, the height of the plants was measured on 40 randomly chosen plants from each cage.

Results

The experiments were heavily influenced by soil variability, thus the plants, in some part of the experimental area, almost stopped growth in the dry period of June, probably due to a lower water capacity of the soil. During this period many buds, flowers and small pods dried out and fell off, leaving podless stalks. In this instance the mean height of the plants was not dependent on the attack ($P>0.2$) and therefore plant height was used as a measure of soil quality.

Attacks from the other two common pests of rape, the seed weevil (*Ceutorrhynchus assimilis* Payk.) and the pod midge (*Dasineura brassica* Win.), were at a very low level, and in the treatment of the results the few destroyed pods were ignored.

However some problems arose with other pests. The rape plants in the area were attacked by the cabbage stem weevil (*Ceutorrhynchus pallidactylus* Marsh.) and the cabbage root fly (*Delia radicum* (L.)). All the plants in the cages were more or less attacked by the larvae of the cabbage stem weevil. The larvae are not regarded a pest on winter rape (12), but *Graham* and *Gould* (5) reported from the U.K. that vigour and yield sometimes can be reduced in spring sown rape. Little is

Table 1. Effect of infestation by pollen beetles on spring sown rape, demonstrated by cage experiments. Seed yield and 1000-kernel weight in grammes.
1) Adjusted means for covariate »height«.
2) Adjusted means for covariate »number of plants«.
Effekt af angreb af glimmerbøsser i vårraps, vist ved hjælp af burforsøg.
Frøudbytte og 1000-korns vægt i gram.
1) Gennemsnit justeret for covariat »højde«.
2) Gennemsnit justeret for covariat »antal planter«.

Mean number of beetles/plant	0	1	2	3½	5	ANOVA	Covariate »height«	Covariate »number of plants«
Mean seed yield per cage 1)	203	248	218	246	261	n.s.	$P<0.01$ $\beta=7.8$ s.e. = 2.51	n.s.
Mean seed yield >2.0 mm. per cage 1)	193	238	196	208	207	n.s.	$P<0.05$ $\beta=7.7$ s.e. = 2.59	n.s. n.s.
Mean number of side-racemes per plant 2)	2.67	3.72	3.74	5.39	5.41	$P<0.001$	n.s.	$P<0.05$ $\beta=-0.057$ s.e. = 0.021
Mean number of pods per plant	37.3	35.8	36.5	42.8	47.3	$P\sim0.05$	n.s.	n.s.
Mean % podless stalks per plant	42.5	52.7	60.0	68.1	68.3	$P<0.001$	n.s.	n.s.
Mean 1000-kernel weight per cage	5.76	5.91	4.84	4.70	4.59	$P<0.05$	n.s.	n.s.
Mean % oil content per cage 1)	40.1	40.6	38.8	39.4	38.9	$P<0.05$	$P<0.001$ $\beta=0.22$ s.e. = 0.048	n.s.

known about the importance on spring sown rape in Denmark, but at low densities, as in this experiment, the larvae are not considered a pest.

Four soil samples (Φ = 7.2 cm) covering one root each were taken from each cage. The mean number of puparia of the cabbage root fly ranged between 0 and 7 per sample, indicating very high densities in some cages. No relationship could be found between the mean number of puparia and seed yield ($P>0.5$), mean plant height ($P>0.5$) or the number of plants ($P>0.5$). In spite of the high densities the occurrence of the cabbage root fly was therefore ignored in the treatment of results, although it is likely that the plants were stressed by their presence.

Statistical tests were performed by ANOVA and ANCOVA (with covariate »mean height« and »number of plants per cage«). The last parameter was included, since different numbers of plants died in the growth period.

The results are presented in Table 1. The seed yield, both the total and the part greater than 2.0 mm was dependent on covariate »mean height« (i.e. soil quality), but not on the size of the attack. Only the number of side racemes per plant showed a weak dependence on the covariate »number of plants«. No influence could be detected between the total number of pods per plant and the size of the attack. Although podless stalks can be caused by other factors, the number shows

a clear dependence on the level of the attack. The relatively high number of podless stalks is due to the summer drought. As more pods on the main raceme are destroyed by the beetles, side racemes are developed. A greater part of the seed yield will then originate from pods situated on side racemes. As these pods have a shorter time to mature, the 1000-kernel weight and the oil-content, will as a consequence decrease. The absolute values of the 1000-kernel weight are very high. It might be caused by the relatively low number of pods remaining after the drought, whereby more resources than normal are allocated to the seeds of these pods.

Discussion

Our results describe some of the qualitative and quantitative changes occurring in spring sown rape after an attack by pollen beetles in the early bud stage.

A highly significant increase in the number of podless stalks occurred as the attack level rose, but the number of pods remained constant with a non-significant tendency to rise. As the pollen beetles arrive on the rape in the early bud stage, chiefly buds on the main raceme are damaged, leaving many podless stalks here. This caused the plants to allocate more resources to the side racemes, thereby producing new buds to replace the damaged ones. The number of side racemes increases significantly with infestation level. By the end of the season, the main part of the yield has shifted from the main raceme to the side racemes due to the pest damage.

When the quality of the yield is considered after an attack by pollen beetles several changes occur. The 1000-kernel weight showed a significant decrease, i.e. the mean size of the seeds is reduced. The oil content of the seed also decreases with infestation at higher densities.

A similar mechanism of compensation has been observed by several authors (6, 7, 9, 15).

Physiological investigations on the factors controlling pod development have been carried out recently revealing that the supply of assimilates from the leaves is essential for normal development of small pods (1, 11, 14). An attack by pollen beetles in the early bud stage retards flowering to the periode when leaf abscission of the plants is in progress. Consequently the supply of assimilates is reduced, when the production of pods begins. This explains the observed qualitative changes.

Although it is clear, that a rape crop is able to compensate for a pollen beetle attack, it is uncertain how effective the compensation is. According to *Nilsson* (9) the compensation ability depends on growing conditions and plant density, and also on the plant growth stages (13).

It seems reasonable to further examine the growing conditions. *Daebler et al.* (2) has found the compensation to be dependent on the amount of nitrogen available. This investigation and the work of *Lerin* (6) on winter rape demonstrate a strong power of compensation even under water stress. This is in contrast to *Nilsson* (10), who has observed an increased sensitivity of the rape plants to attack by pollen beetles during dry and warm periods, where the flowering period is short (10). This difference might be explained by tip-dropping (due to high attack levels) in the Swedish experiments.

The dependence on plant density is obvious, when comparing the present results with those of *Nilsson* (9). In his experiments the average plant density was 230 plants/m^2, probably limiting side raceme development. In Danish rape fields densities are about 130 plants/m^2 and our results show, that in this case the plants have a strong ability to develop side racemes.

Thus, when an economic threshold has to be etablished, both the number of beetles per plant and the number of plants per m^2 should be considered. In spring rape in Sweden *Nilsson* (9) found the average economic threshold level to be 0.8 beetles/plant. Due to the much lower plant density in Danish fields and the resulting possibility of compensation this figure might be too low under Danish condition.

If a reduction in the mean size of the seeds represents the most serious changes after an attack by pollen beetles, as suggested by this investigation, more seeds than normal will be lost during the cleaning process. This factor has still to be investigated.

This investigation is not comprehensive enough for establishing an economic threshold for Danish rape fields. Further, the results of the experiment are subject to a considerable variance, mainly due to the fact that small cages produce large variance in the yield on a weight basis. Cage experiments are inadequate for detecting the small changes in yield observed in crops, which are able to compensate for damage caused by a pest attack.

Acknowledgements

We thank the owner of the rape field for placing research area at our disposal, and also Dr. *Boy Overgaard Nielsen* for reviewing the manuscript, offering suggestions and criticisms. We thank Dr. *Fritjof Lind* and Dr. *Christer Nilsson* for encouragement and inspiring discussions. Further we thank Dr. *Jørgen Granfeldt Petersen* and employees at Aarhus Oil Factory Ltd., The Pajbjerg Foundation and The Danish Seed Testing Station for helpful assistance.

This work was financially supported by Aarhus Oil Factory Ltd. and also by a grant from The Knud Højgaard Foundation.

References

1. *Allen, E. J. & Morgan, D. G.* 1975. A quantitative comparison of the growth, development and yield of different varieties of oilseed rape. J. agric. Sci., Camb. 85, 159-174.
2. *Daebler, F., Röder, K., Hinz, B. & Lücke, W.* 1980. Schadwirkung des Rapsglanzkäfers bei unterschiedlich hohen Stickstoffgaben. Nachrichtenblatt für den Pflanzenschutz in der DDR 34, 13-15.
3. *Free, J. B. & Williams, I. H.* 1979a. The distribution of insect pests on crops of oilseed rape (*Brassica napus* L.) and the damage they caused. J. agric. Sci., Camb. 92, 139-149.
4. *Free, J. B. & Williams, I. H.* 1979b. The infestation of crops of oilseed rape (*Brassica napus* L.) by insect pests. J. agric. Sci., Camb. 92, 203-218.
5. *Graham, C. W. & Gould, H. J.* 1980. Cabbage stem weevil *(Ceutorrhynchus quadridens)* on spring oilseed rape in Southern England and its control. Ann. appl. Biol. 95, 1-10.
6. *Lerin, L.* 1987. Compensation in winter rape following simulated pollen beetle damage. Bulletin SROP X/4, 57-63.
7. *Lind, F.* 1985. Pollen beetle (*Meligethes aeneus* F.) damage to spring oil seed rape in various plant growth stages. In: *Sörensen, H.* (ed.): Advances in production and utilization of cruciferous crops. Dordrecht, pp. 254-259.
8. *Harper, F. R. & Berkenkamp, B.* 1975. Revised growth-stage key for *Brassica campestris* and *B. napus*. Can. J. Plant Sci. 55, 657-658.
9. *Nilsson, C.* 1987. Yield losses in summer rape caused by pollen beetles *(Meligethes spp.)*. Swedish J. agric. Res. 17, 105-111.
10. *Nilsson, C.* 1988. Pollen beetles (*Meligethes aeneus* F.) and flowering in rape. Swedish J. agric. Res. 18, 113-118.
11. *Pechan, P. A. & Morgan, D. G.* 1985. Defoliation and its effects on pod and seed development in oil seed rape (*Brassica napus* L.). J. Exp. Bot. 36, 458-468.
12. *Saringer, G.* 1978. Problems with *Ceutorrhynchus quadridens* Panz. *(Col.: Curculionidae)* in Hungary. In: 5. International Rapeseed Conference Vol. 1. pp. 315-317. Malmö, Sweden.
13. *Sylvén, E. & Svensson, G.* 1976. Effect on yield of damage caused by *Meligethes aeneus* F. (Col.) to winter rape, as indicated by cage experiments. Ann. Agric. Fenn., 15, 24-33.
14. *Tayo, T. O. & Morgan, D. G.* 1979. Factors influencing flower and pod development in oilseed rape (*Brassica napus* L.). J. agric. Sci., Camb. 92, 363-373.
15. *Tatchell, G. M.* 1983. Compensation in spring sown oil-seed rape (*Brassica napus* L.) plants in response to injury to their flower buds and pods. J. agric. Sci., Camb. 101, 565-573.
16. *Tulisalo, U., Korpela, S. & Pohto, A.* 1976. The yield loss caused by the seedpod weevil (*Ceuthorrhynchus assimilis* Payk. *(Col., Curculionidae))* on summer turnip rape in cage experiments. Ann. Entomol. Fenn. 42, 98-102.
17. *Williams, I. H.* 1978. The pollination requirements of swede rape (*Brassica napus* L.) and of turnip rape (*Brassica campestris* L.). J. agric. Sci., Camb. 91, 343-348.
18. *Williams, I. H. & Free, J. B.* 1979. Compensation of oilseed rape (*Brassica napus* L.) plants after damage to their buds and pods. J. agric. Sci., Camb. 92, 53-59.

Manuscript received 8 February 1990.