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THE INSECT PESTS OF OIL SEED RAPE

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During the past decade the amount of oil seed rape grown for seed in England has increased greatly. Before 1966, only 1,300 ha of rape were grown annually, compared with 57,000 ha in 1977; the amount grown is likely to continue to increase. In order to obtain information about the pests of this crop a general survey was made in 1973 of pest damage to 19 crops of winter rape and 22 crops of spring rape in south-central England; also in 1973, 1974 and 1975, 10 crops of winter rape and two crops of spring rape were sampled more intensively for insect pests and pest damage once or twice a week from green bud stage to just before harvest.

The most common pests were pollen beetle (*Meligethes aeneus* Fab.) and seed weevil (*Ceutorrhynchus assimilis* Payk.); the former was usually the more numerous, especially on spring rape crops. Stem weevil (*Ceutorrhynchus quadridens* Panz.) and pod midge (*Dasyneura brassicae* Winn.) were less abundant.

CROP INFESTATION

Before rape crops flowered, pollen beetles and seed weevils fed, often in great numbers, in the flowers of plants, growing on crop verges. However, whereas, pollen beetles were found in plants of many families, seed weevils were confined to cruciferous plants. Wild crucifers are not only an important source of food for seed weevils before and after infestation of rape but their presence in or near crops encourages immigration of weevils so it would seem desirable to keep crops and their verges free from early flowering cruciferous weeds.

Pollen beetles and seed weevils flew to winter rape crops when temperatures exceeded 15^{o}C. Pollen beetle immigration occurred during April, at either green bud stage, when flowering began, or at full flower depending on the temperature. Maximum numbers occurred on the crop before or during flowering. Seed weevils may move to rape because they prefer the cultivated plant to wild crucifers for oviposition. They enter the crop during April and early May, before or at the beginning of flowering, with maximum infestation during flowering from mid- to late May. Pod midge occurred on winter crops during June and July while crops were in full flower and had two generations per year. A third generation may infest spring rape crops where these are grown nearly, although pod midge did not infest the spring rape crops sampled. In response to changing temperatures successive waves of pest immigration to winter rape sometimes occurred. Immigration of pollen beetles and seed weevils to spring rape occurred at green bud stage during early June; maximum daily temperatures during June exceed the flight threshold temperate so immigration was not curtailed by temperature and was closely synchronised with the development of the crop. The two methods used for sampling pests, sweep nets and water traps, gave different results. Water trap collections primarily reflected pest flight, and were not necessarily related to the pest population of the crop.

The proportion of male to female pollen beetles and seed weevils present on crops varied. The ovaries of pollen beetles matured between the beetles' emergence from hibernation and migration to winter rape. Beetles began egg laying soon after arrival on spring rape but not until three weeks after arrival on winter rape. Because buds suitable for oviposition were present on arrival on winter rape and females contained eggs, this delay may have been because the adults were not ready to mate. None were seen paired before the beginning of May. Eggs were laid in buds, usually between the anthers and the ovary, but not in the flowers. Larvae moved from flower to flower up the raceme feeding on pollen but caused no damage even when ten were present per flower. Seed weevils fed for three to four weeks after arrival on winter rape before their ovaries matured and they had mated, but began laying as soon as pods of suitable length were present on spring rape. When presented with pods of different lengths in the laboratory, seed weevils preferred to lay in those of medium length. Many pollen beetles and seed weevils contained eggs until late July.

On both winter and spring crops, numbers of pollen beetles declined during flowering, in early and late June, respectively, and numbers of seed weevils declined while pods were maturing. Their decline on winter rape resulted from emigration to new host plants, including spring rape. New generation pollen beetles emerged before winter and spring rape were harvested, and new generation seed weevils emerged before spring rape but not winter rape was harvested. They did not mate and their ovaries remained immature. When crops ceased to flower, they moved in large numbers to verge plants which appear to be a particularly important source of forage for accumulation of food reserves for hibernation. After a few weeks of feeding, they entered overwintering sites.

DAMAGE CAUSED BY PESTS

Rape buds and flowers that fail to set pods fall from the plant leaving podless stalks. This damage has been attributed to pollen beetles. Adults that arrived before a crop flowered, fed on buds, perforating them to obtain pollen, but only some of these buds abscissed. The sepals and petals of most damaged buds were chewed but the gynoecia, from which the pods develop, were not damaged. When flowering began, pollen beetles preferred to fed on the accessible pollen in flowers, rather than in buds. Although the percentage of podless stalks on winter crops surveyed ranged from 1.8 - 23.3% (mean 11.7%) and on spring crops from 2.7 - 19.6% (mean 9.4%) these percentages were not correlated with the seed or pod yield of plants, the commercial seed yield, the number of years rape had been grown on the farm, or the location on the crop. The percentage of podless stalks is unlikely to be correlated with pollen beetle abundance, because the mean percentage was similar on winter and spring rape, although pollen beetles are relatively more abundant on the latter. The percentage of podless stalks at the edge and centre of crops were also similar, although pollen beetles are usually more abundant at the edge.

Probably, therefore, counts of podless stalks do not give a reliable estimate of pollen beetle damage; many are probably caused by physiological factors. Even cross-pollinated plants, grown in a glasshouse from which insects were excluded, set only 68% of their flowers and the remainder fell, leaving podless stalks. The presence of numerous podless stalks at raceme tips has been attributed to damage by pollen beetle larvae. However, flower set on the terminal raceme declined steadily from the lowest to the uppermost flower; when the top third of the terminal raceme has less than 25% set there are many podless stalks at raceme tips, irrespective of the presence of pollen beetle larvae.

During their early period of infestation of winter rape, adult seed weevils fed on the buds, in flowers, pods and stem tips but not elsewhere. Small tender pods were preferred to larger mature ones. Feeding on pods, however, caused no damage at this stage; they were not deformed and no ovule abortion or seed loss was recorded.

The percentage of pods infested by seed weevil larvae increased with the adult seed weevil population. The mean percentage of pods infested with larvae ranged from 2.4 - 25.7 (mean 10.4) on the winter crops and 0.4 - 12.0 (mean 4.5) on the spring crops surveyed. In winter rape crops infestation of pods increased with the number of years rape had been grown on a farm, but this was not so for spring rape. New generation weed weevils spent much time feeding before hibernation; they caused some loss of seed weight and viability when feeding on pods of spring rape in an insectary, but this is probably insignificant on a field scale. Winter rape is harvested before the emergence of new generation seed weevils and therefore escapes damage at this stage.

Seed weevil larvae dimished the weight of seed of infested pods by 18 - 19%. Although the larvae had completely eaten a mean of only 1.4 and 1.8 seeds per winter and spring rape pod, respectively, the remaining seeds weighed less than those in intact pods, presumably because many more seeds had been partially eaten. The yield loss of about 18% in seed weevil infested pods and the mean infestation of 10.4% and 4.5% in pods of winter and spring rape respectively, would give an overall loss in seed yields of only 1.9% and 0.8% respectively. Similarly the maximum infestation of 25.7% pods among the winter rape crops would give an expected loss in seed yield of only 4.6%.

Only two of the winter and none of the spring rape crops surveyed had many pod midges. In these two fields both adult pod midge and split pods decreased progressively from the field edge to the field centre. The pod midge larvae were largely confined to the field edges.

ABILITY OF PLANTS TO COMPENSATE FOR INJURY

Rape plants were capable of much compensation. Seed weevil damage was probably partly compensated for, because the weight per seed increased as the number of seeds per plant diminished. Yield loss was always less than the proportion of buds or pods removed experimentally or injured. No yield loss resulted when up to 25% of pods contained seed weevils in the field, or from removal of 60% of pods, or from removal of up to half, and in some experiments more, of the flowers.

Late removal of buds or pods sometimes caused greater yield loss than early removal, and late pod removal often resulted in more immature pods at harvest. However, most pollen beetle injury occurs before flowering when adults feed and lay their eggs in the buds; once the first flowers have opened, they are preferred to buds for feeding and the pollen beetles do little damage to them. Hence, any injury by pollen beetles occurs early in the flowering period, allowing time for the plant to compensate. By contrast seed weevils prefer to lay their eggs in pods of medium length and because the rate of injury increases as the larvae grow, compensation for late injury by seed weevil may result in immature pods at harvest, making control measures desirable. The effect of different concentrations of seed weevil and pollen beetle on seed yield is being investigated.

DISTRIBUTION AND CONTROL OF PESTS

Because pests invade rape crops in succession, and have prolonged periods of immigration, it is unlikely that a single application of insecticide would affectively control crop infestation by one or more pests. Clearly, the optimum time of treatment would be when maximum pest numbers are present but before any damage has occurred. Most pollen beetle damage is done by adults at green bud stage, whereas most seed weevil damage is done by larvae when pods are lengthening and it is not easy to control their numbers at times when the crop is not in flower.

In the 1973 survey, about a third of winter rape crops and more than three-quaters of spring rape crops were treated with insecticide, and insecticide usage increased with the number of years that spring rape had been grown on a farm. However, no yield benefit was evident.

Early in the season there were relatively more pollen beetles and seed weevils at the crop edge than in the crop. However, whereas the larvae of pod midge were largely confined to the edges of crops, larvae of pollen beetles and seed weevils were more evenly distributed over the crops than the adults. Possibly, competition for oviposition sites caused the spread of females over the crops. In lightly infested crops usually more weevil-infested pods were present at the edges than at the centres, but the opposite tended to occur in heavily infested crops, probably because adult populations spreading from the edges converged at the centres of fields.

The greater numbers of adult pollen beetles and seed weevils at the edges of crops suggest that insecticide treatment of crop borders alone may diminish populations of these pests, particularly if applied during the period of immigration when the proportion at the edge is greatest, and particularly on large fields, where this effect is more pronounced than in small fields.

The proportion of pests on the crop edge varied with crop area, the size of the pest populations, and from day to day, so the width of any border treatments probably needs to be assessed for each crop, on the basis of counts of insects made just before treatment. Treatment of the borders only with insecticide is cheaper and causes less damage to the crop and beneficial insects, including honeybees, and parasites of the pests.

Probably insecticide would be best applied in the bud stage and during good weather when the pests are exposed and are not protected inside the flowers.

Unless border treatments are frequent and effective enough to prevent the spread of seed weevils into the crop during immigration, effective seed weevil control would seem to be dependent upon insecticide application during flowering.

If control of pod midge is to depend on control of the seed weevil then seed weevil numbers should be kept small throughout their immigration period; delaying control of the seed weevil until just before oviposition would not prevent pod midge damage because seed weevils have a prolonged period of feeding on the crop before they oviposit and pod midges oviposit through seed weevil feeding punctures.

Although pod midge adults, and especially their larvae were largely confined to the edges of crops, the adults live for only 1 - 3 days so that by the time they are seen on a crop and effective action taken to control them, much of the damage will have been done. Because the time of infestation varied from late May to late June successful control of this pest clearly requires more knowledge of the factors influencing its emergence from hibernation, so that border treatments can be propitiously timed.

In order to explore the possibility of control methods other than by insecticides, studies have been made of the factors eliciting responses of the pollen beetle and seed weevil to their host and non-host plants. Seed weevils showed no innate preference for particular plant species, but soon became conditioned to the plants on which they were feeding and subsequently preferred them. There was no indication that any of the wild species visited by pollen beetles or seed weevils were sufficiently preferred to rape for them to be used as bait crops.

Pollen beetles and seed weevils were attracted to traps baited with extracts of cruciferous plants or the mustard oil, allylisothiocyanate. Although the attraction to the allylisothiocyanate baited traps was not sufficiently great to be used for control purposes, the results obtained do not exclude the possibility that more efficient traps and baits could be developed.