Effect of sowing rate on the infestation of winter oilseed rape by stem-boring pests and on yields

Helene Nuss, Bernd Ulber

Department of Crop Sciences, Plant Pathology and Crop Protection Division, Entomology Section, University of Goettingen, Grisebachstrasse 6, D-37077 Goettingen, Germany
Email: bulber@gwdg.de

Abstract

The effect of sowing rate and the resulting plant density and plant architecture on the larval infestation of winter oilseed rape by cabbage stem flea beetle, *Psylliodes chrysocephala* L., rape stem weevil, *Ceutorhynchus napi* Gyll., and cabbage stem weevil, *Ceutorhynchus pallidactylus* (Mrsh.), was studied in three field experiments in 1999/00, 2000/01 and 2001/02. Sowing rates of 30, 60 and 90 seeds/m² (2001/02: 30 and 60 seeds/m²) were compared in randomised block experiments with 6 replicated plots for each treatment. An open-pollinating cultivar was sown in 1999/00 and a hybrid cultivar in 2000/01 and 2001/02. The abundance and within-plant distribution of larvae was determined from plant samples. Petioles and stems were dissected under a microscope. Seed yield was assessed at harvest.

The sowing rate of 30 seeds/m² resulted in significantly lower plant density and oilseed rape plants of significantly larger size and higher numbers of leaves and lateral buds. At 30 seeds/m², the number of stem-boring larvae/plant was significantly greater compared to high sowing rates (60 and 90 seeds/m²). In contrast, the number of stem weevil larvae/m² was little affected by plant density; only the number of *P. chrysocephala* larvae/m² increased with increasing plant density in all years. The different plant architecture in plots of various plant density resulted in different within-plant distributions of larvae in shoots and leaves. This was possibly due to the oviposition preference of females for specific plant growth stages and organs. Seed yield and the 1000-kernel-weight was not affected significantly by plant density. Despite of higher levels of stem infestation at low plant density, the seed yield per plant significantly increased as plant density decreased. The results provide evidence that reduced seed rates of oilseed rape which are increasingly used by European rape growers do not increase the damage potential of stem-boring pests.

Key words: Oilseed rape, sowing rate, stem-boring pests, *Psylliodes chrysocephala*, *Ceutorhynchus napi*, *Ceutorhynchus pallidactylus*, yield

Introduction

Crops of winter oilseed rape frequently show large variations of plant density and growth of individual plants. Depending on sowing rate and crop establishment, plant density in spring may vary between <30 and >100 plants/m². In Germany, recent recommendations for growing hybrid cultivars suggest sowing rates of only 30 – 50 seeds/m² (Sauermann & Gronow, 2000; Baer & Frauen, 2003), resulting in crops of very low density and large,vigorous plants. The consequences of these changes for pest infestation and damage have not been studied before. The aim of our study was to determine the effect of various plant densities and the resulting plant architecture of winter oilseed rape on larval abundance, within-plant distribution and damage potential of three major stem-boring pests.

The cabbage stem flea beetle, *Psylliodes chrysocephala* L. (Col.: Chrysomelidae) invades the establishing crop in August/September. Adults feed on young leaves, causing damage to slowly germinating plants. The larvae mine in petioles and stems from October to May, thereby weakening the plants, promoting the severity of fungal stem infections and increasing plant mortality during winter. The rape stem weevil, *Ceutorhynchus napi* Gyll., and the cabbage stem weevil, *Ceutorhynchus pallidactylus* (Mrsh.)(Col.: Curculionidae) colonize crops of oilseed rape in March/April. Eggs are layed into elongating stems and petioles, respectively. Larvae of both species mine within plants, causing distortion of stem tissue and loss of vigour. High levels of infestations can result in considerable damage to the crop (Alford et al., 2003; Williams, 2004).

Material and Methods

The field experiments were laid out in 1999/2000, 2000/01 and 2001/02 at one site at Goettingen (Northern Germany), using sowing rates of 30 seeds/m², 60 seeds/m² ans 90 seeds/m² (2001/02: 30 and 60 seeds/m²) and 13 cm row spacing. Plots were arranged in a complete randomized block design and sown with the OP winter rape cv 'Mohican' in August 1999 and the hybrid cv 'Artus' in August 200 and 2001. Each sowing rate was replicated in six plots of 300 m² each. To prevent plant losses during winter caused by severe attack of
P. chrysocephala, an insecticide was applied over all plots in all years following sampling of plants in November.

The number of plants as well as stem length and diameter, number of leaves and number of lateral racemes were recorded in each plot in November and April. The abundance and spatial distribution of plant-mining larvae within petioles and stems was assessed from samples of 15 plants/plot, collected randomly along a diagonal transect across the plot, in late November (*P. chrysocephala*) and in May (*C. napi, C. pallidactylus*). In the laboratory, stems and leaves were dissected under a microscope and the number of larvae from different positions within plants was recorded. Seed yield was assessed at harvest.

Results and Discussion

In all years of the experiment, plant numbers among the three sowing-rate treatments showed significant differences in autumn and spring (Table 1). In 1999, the number of plants in all plots was increased by emerging volunteer rape. In 1999/2000 and 2000/20001, only in plots of 90 seeds/m² was the plant density significantly reduced during winter, indicating a higher winter mortality at high plant density. At low plant density (30 seeds/m²), the plant architecture showed significant differences compared to higher plant density. The number of leaves/plant, the number of lateral racemes and the diameter of the main stems was greater at lower plant density.

Table 1. Mean plant density (number of plants/m²) in plots of various sowing rates in 1999/00 - 2001/02

Sowing rate	1999/2000		2000/2001		2001/2002	
	Autumn*	Spring	Autumn	Spring	Autumn	Spring
30 Seeds/m²	40.8 a A	37.4 a A	26.8 a A	30.0 a A	28.5 a A	23.8 a B
60 Seeds/m²	68.4 b A	65.9 b A	49.3 b A	54.1 b A	57.3 b A	50.1 b B
90 Seeds/m²	102.6 c A	82.1 c B	86.2 c A	76.4 c B	-	-

* = plant numbers influenced by emerging volunteer rape
Independent samples: ANOVA, Tukey-Test, $p < 0.05$; bound samples: t-Test, $p < 0.05$
Different uppercase and lowercase letters indicate significant differences between seasons and between sowing rates, respectively.

In all years of study, the abundance of *P. chrysocephala* larvae/m² decreased with decreasing number of plants/m² (Figure 1). In contrast, the number of larvae/plant significantly increased as plant density decreased. The within-plant distribution of larvae was only affected in 2000 when the vigorous growth in autumn of the hybrid cv 'Artus' enabled an early development of lateral buds at low plant density. Consequently, significantly more larvae invaded these buds, thereby preventing the most damaging infestation of terminal buds.

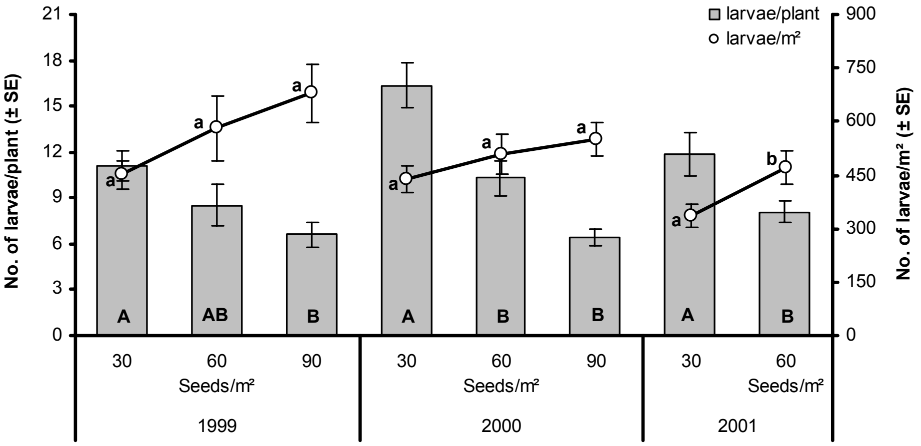

Fig. 1. Mean number of *P. chrysocephala* larvae (± SE) per plant and per m² in plots of various sowing rates in 1999-2001. Different uppercase and lowercase letters indicate significant differences between sowing rates within each year (ANOVA, Tukey-Test, $p < 0.05$)

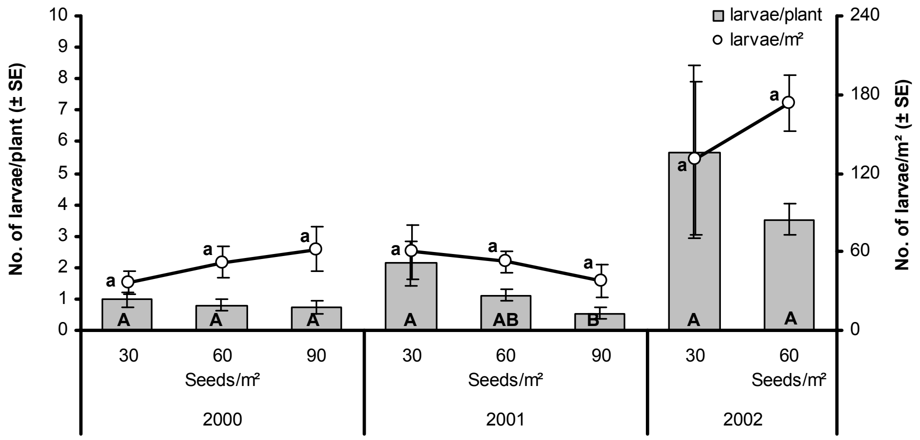

Fig. 2. Mean number of *C. napi* larvae (± SE) per plant and per m² in plots of various sowing rates in 2000-2002. Different uppercase letters indicate significant differences between sowing rates within each year (2000 and 2001: ANOVA, Tukey-Test, 2002: Mann-Whitney U-Test, $p < 0.05$)

The number of *C. napi* larvae per plant increased as the number of plants/m² decreased, but this effect was only proven to be statistically significant in the year 2001 (Figure 2). At 30 seeds/m², a significantly higher proportion of larvae developed within lateral racemes. This effect was found to depend on the growth stage and branching ability of plants, the cultivar and the level of larval infestation. The effect of plant density on the abundance of *C. napi* larvae per unit area (m²) varied between years.

In all years, the number of *C. pallidactylus* larvae per plant increased with decreasing plant density (Figure 3). Similar to *C. napi*, the abundance of larvae per m² was not affected significantly by sowing rate. Female *C. pallidactylus* in plots of different plant density probably distributed their egg load to the available plants. At 30 seeds/m², the resources provided by the larger number of leaves per plant were sufficient for complete oviposition and development of larvae.

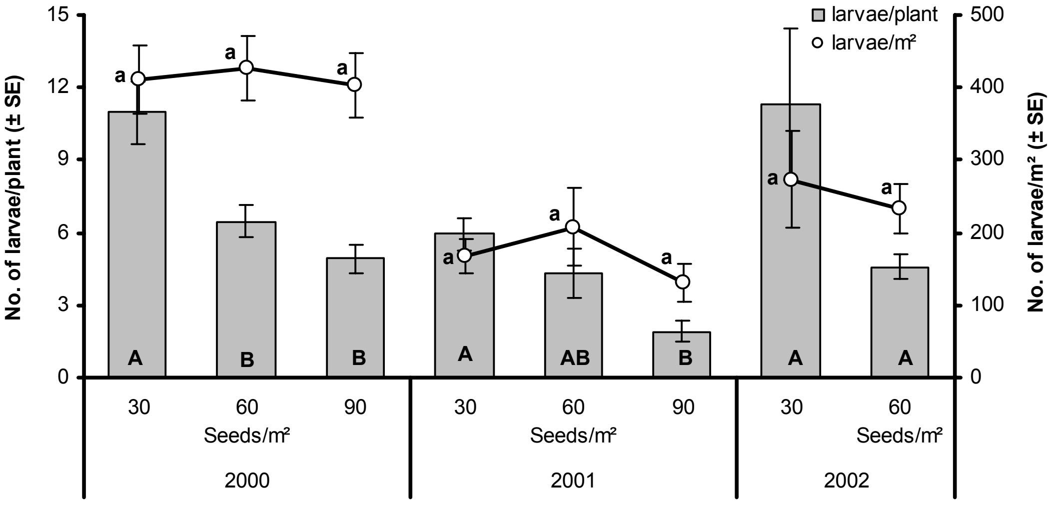

Fig. 3. Mean number of *C. pallidactylus* larvae (± SE) per plant and per m² in plots of various sowing rates in 2000-2002. Different lowercase and uppercase letters indicate significant differences between sowing rates in each year (2000 and 2001: ANOVA, Tukey, $P < 0.05$; 2002: Mann-Whitney U-Test, $P < 0.05$)

In all years, the seed yield per ha was not affected significantly by the different sowing rates (Table 2). In contrast, the yield per plant increased significantly as the number of plants/m² decreased. Plants in sparse populations grow larger and produce more pods and seeds per plant than in densely spaced crops (Leach et al., 1994). They produce larger stems, more leaves and more lateral racemes than plants grown at high density, thereby diverting part of the stem-boring pest larvae away from the most susceptible main stems and terminal buds.

Former studies have shown that an increase in crop plant density can be used as a measure of pest control (Way & Heathcote, 1966; Dosdall et al., 1999; Dosdall et al., 2003), or can have variable effects on different pest species (Mayse, 1978; Dechert & Ulber, 2004). Our results provide evidence that oilseed rape plants grown at low density, although subjected to higher levels of infestation by stem-boring pests, have a higher ability to compensate for larval damage. Thus even under high pressure of pest infestation, yield per unit area was not affected negatively by reduced sowing rates of winter oilseed rape.

Table 2. Mean seed yield (t/ha) and yield per plant (g/plant) (± SE) in plots of various sowing rates in 1999/00 to 2001/02

	Sowing rate	1999/2000	2000/2001	2001/2002
Yield (t/ha)	30 Seeds/m²	3.16 (0.12) a	3.94 (0.03) a	3.11 (0.09) a
	60 Seeds/m²	3.38 (0.08) a	4.12 (0.06) a	2.89 (0.08) a
	90 Seeds/m²	3.37 (0.14) a	4.10 (0.07) a	-
Yield (g/plant)	30 Seeds/m²	8.5 (0.3) a	13.5 (1.1) a	13.0 (0.6) a
	60 Seeds/m²	5.1 (0.1) b	7.7 (0.3) b	5.9 (0.2) b
	90 Seeds/m²	4.1 (0.2) c	5.4 (0.2) b	-

Means followed by different letters indicate significant differences between sowing rates. 1999/00 and 2000/01: ANOVA, Tukey-Test, $P < 0.05$; 2001/02: Mann-Whitney U-Test, $P < 0.05$

Acknowledgements

This study was funded by the German Research Council (DFG)-PhD programme ‚Agriculture and the Environment' and by the EU-funded Framework 5 Quality of Life and Management of Living Resources project MASTER, 'Integrated pest management strategies incorporating bio-control for European oilseed rape pests' (QLK5-CT-2001-01447).

References

Alford, D.V., Nilsson, C. & Ulber, B. (2003). Insect pests of oilseed rape crops. *Biocontrol of Oilseed Rape Pests*. (ed. by D.V.Alford). pp. 9-41. Blackwell Publishing, Oxford, U.K.

Bear, A. & Frauen, M. (2003). Yield responses of winter oilseed rape hybrids to sowing date, sowing density, nitrogen supply and triazol input. Proceedings of the 11th International Rapeseed Congress, Copenhagen 6.-10. July 2003, 887-889.

Dechert, G. & Ulber, B. (2004). Interactions between the stem-mining weevils *Ceutorhynchus napi* Gyll. and *Ceutorhynchus pallidactylus* (Mrsh.) (Coleoptera: Curculionidae) in oilseed rape. Agricultural and Forest Entomology **6**, 193-198.

Dosdall, L.M., Dolinski, M.G., Cowle, N.T. & Conway, P.M. (1999). The effect of tillage regime, row spacing, and seeding rate on feeding damage by flea beetles, *Phyllotreta* spp. (Col.: Chrysomelidae) in canola in central Alberta, Canada. Crop Protection **18**, 217-224.

Dosdall, L.M., Clayton, G.W., Harker, K.N. & O'Donovan, J.T. (2003). Insect – agronomic interactions in canola integrated pest management. Proceedings of the 11th International Rapeseed Congress, Copenhagen 6.-10. July 2003, 1051-1053.

Leach, J.E., Darby, R.J., Williams, I.H., Fitt, B.D.l. & Rawlinson, C.R. (1994). Factors affecting growth and yield of oilseed rape (*Brassica napus*), 1985-89. Journal of Agricultural Science, Cambridge, **122,** 405-413.

Mayse, M.A. (1978). Effects of spacing between rows on soybean athropod populations. Journal of Applied Ecology **16**, 439-450.

Sauermann, W. & Gronow, J. (2000). Anbautechnik von Hybridraps. Ist eine sorten- und standortspezifische Intensität möglich? Raps **18**, 4-8.

Way, M.J. & Heathcote, G.D. (1966). Interactions of crop density of field beans, abundance of *Aphis fabae* Scop., virus incidence and aphid control by chemicals. Annals of Applied Biology **57**, 409-23.

Williams, I.H. (2004). *Advances in Insect Pest Management of Oilseed Rape in Europe.* Insect Pest Management - Field and Protected Crops. (ed. by A.R. Horowitz & I. Ishaaya). pp. 181-208. Springer-Verlag, Heidelberg.