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ASSESSMENT OF PLANT DAMAGES AND INTENSITY OF *DEROCERAS RETICULATUM* (MÜLLER) OCCURRENCE IN WINTER OILSEED RAPE AND WINTER WHEAT

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Abstract: The rate of damages caused by the field slug *Deroceras reticulatum* to winter oilseed rape and winter wheat was investigated under field and laboratory conditions. The number and degree of seedling damages were estimated on the basis of the intensity of slug occurrence, which were caught in baited traps. It was found that over a 3–4-week period after sowing, damages caused by *D. reticulatum* slugs constituted 60% in young oilseed rape and 40% in wheat plants. Under laboratory conditions, one slug damaged almost completely 10 rape seedlings (95%) during 13 days of its feeding. The percentage damage caused by the pest to wheat seedlings was considerably lower (53%), whereas wheat seeds appeared to be severely damaged (83%) after 9 days of the slug feeding.

Key words: *Deroceras reticulatum*, harmfulness, oilseed rape and wheat

INTRODUCTION

Winter oilseed rape and winter wheat grown in a temperate climate are frequently damaged by the field slug – *Deroceras reticulatum* (Müller). The highest damages are observed in the countries of Central and Western Europe. Oilseed rape is a crop sensitive to slug attacks, for instance in Germany (Mesch 1996) and Switzerland (Högger 1995; Frank 1998a; 1998b), and wheat – in Great Britain (Glen et al. 1993). The reasons of the slug population increase are a simplified soil cultivation system without ploughing applied in many countries and direct sowing (Glen et al. 1994; Kendall et al. 1995; Frank 1998a). Plants of oilseed rape are damaged mainly during the early, vulnerable stages of their development, as soon as the very first

seedlings appear (Frank 1998a; Moens et al. 1992), whereas wheat is damaged immediately after sowing, prior to plant emergence (Gould 1961; Duthoit 1964; Cook et al. 1997). In Poland, damages caused by the field slug to oilseed rape and wheat crops are increasing, particularly in the south-west regions of the country (Kozłowski 1999). The reasons of that are meteorological conditions favorable to the development of slugs and changes in the method of tillage.

The aim of the observations presented in this paper was to assess the rate and degree of damages caused by the slug to young plants of oilseed rape and wheat depending on its population numbers.

MATERIAL AND METHODS

Field studies. The studies were carried out in autumn 2001 in two fields of Opole province, which were sown with the winter oilseed rape cv. Lisek (a 0.6-ha field at Maciowakrze) and winter wheat cv. Kobra (a 3.3-ha field at Biernatów). The crops under study were managed using a simplified system on heavy soils with a loamy substratum and a high content of unequally distributed plant remnants left after harvesting. A forecrop for the both studied crops was winter rape. Plants in the winter oilseed rape crop were obtained from the secondary sowing performed in a ploughed field on 8 September after winter rape, which was damaged to 70% by slugs. Winter wheat was sown at the end of September (29.09.). Crop inspections carried out several days after the emergence of plants revealed plant damages and the presence of the field slug (*D. reticulatum*). The performed field inspections showed that the both studied crops had places deprived of plants, which were damaged before and immediately after their emergence.

Observations began 6–9 days after the emergence of plants and were conducted once a week for three consecutive weeks in the field of oilseed rape and for two consecutive weeks in the field of winter wheat. When the trials began, rape plants were at the stage of the first 2–4 leaves and wheat plants – at the stage of 1–2 leaves.

Twenty observation places, covering 50 plants and located 20–25 m apart (a systematic layer sample), were randomly fixed up in each studied field at each observation date. Slug traps were baited close to them. They were pot plates 30 cm in diameter, laid upside down on the soil surface. The granulated (Anti-Slug) molluscicide Anty-Ślimak Spiess 04 GB (4% metaldehyde) in the amount of 0.4 g was sown under each pot plate. In the evening, the slug traps were placed in the crops and the next day in the morning the caught slugs were counted and divided into two size classes according to their length (>1 cm and <1 cm lengths).

Damage degrees of 50 plants were assessed at the observation places using a 5-degree scale, according to which: 0 = no damage; 1= 1–25%; 2 = 26–50%; 3 = 51–75%; 4 = 76–100% of damaged plant area. A 100% plant damage in the case of rape indicated that leaf blades were completely damaged and that there were only stem remains, whereas in the case of wheat that denoted seed damage or leaf excision.

Observations on the damage degree of 50 plants were used to determine the following values for each observation place: mean degree of plant damage, % of plant part damaged above-ground and % of the number of damaged plants. The applied

correlation and regression analyses permitted to evaluate the relations between the degree of plant damages and slug numbers for each observation date. The Student t-test was also used to find the significance of changes in the intensity of the field slug occurrence and in the degree of plant damages. The critical significance level p was determined.

Laboratory studies. The studies were conducted under controlled conditions in the environmental chamber at the day temperature of 18°C and night temperature of 15°C, RH 93% and 15 h day length. Ten seeds of winter oilseed rape (cv. Kana) or winter wheat (cv. Kobra) were sown per translucent plastic box, the base of which was covered with 5 cm of humous soil. These boxes (dimensions 18 × 12 × 10 cm) were closed and provided with two holes covered with mill gauze. When the plants reached the height of 5–8 cm (rape had 2–4 and wheat – 1–2 true leaves), one *D. reticulatum* specimen, starved for 24 hours, was put in each box. The mean slug weight was 0.7 g for oilseed rape and 0.6 g for wheat. The number and degree of seedling damages were determined (according to the mentioned 5-degree scale) once a day for 13 consecutive days. Twenty replications were carried out for each plant species. The obtained results of the studies were compared for each day separately using the Student t-test. The critical significance level p was determined.

The damage rate and percentage of winter wheat seeds (cv. Kobra) damaged by *D. reticulatum* were determined under the same conditions (temperature, moisture and day length). The bottom of each box was lined with a moist filter paper to place 10 seeds on it at appropriate numbered places. After 24 hours, one starved slug was introduced into each box. The mean slug weight was 0.5 g. The number of damaged seeds was assessed once a day for 9 consecutive days. The experiment was carried out with 10 replications. Correlation and regression analyses were carried out.

RESULTS

Field studies. The mean degree of plant damages in the oilseed rape crop in the first week of observations was 1.3 and ranged from 0.6 with an average of 20 slugs per trap to 2.5 with an average of 45 slugs per trap (Tab. 1). In the second week, the mean damage degree increased highly considerably up to 2.9 ranging from 2.2 with, on the average, 21.5 slugs per trap to 3.6 with 38.2 slugs per trap. The largest number of slugs was caught on the plots with a large nutrition base (the lowest % of plants damaged above the ground was equal to 37.3%). In the third week, the mean damage degree amounted to 3.3 and ranged insignificantly between 2.9 to and 3.5 when the mean number of caught slugs per trap ranged between 18.0 and 45.7. No significant differences were found in the degree of plant damages between the second and third weeks of observations. The mean percentage of all plants damaged to whichever degree ranged from 44% to 80% in the first week, between 95% and 100% in the second week, while in the third week all the plants were damaged (100%). However, the mean percentage of plants damaged to the highest degree (4) at the successive dates amounted to 14.9%; 49.6% and 59.4%, respectively, and did not depend on the number of caught slugs (Tab. 1). The mean number of slugs in oilseed rape crop for three consecutive weeks maintained on a similar level. The mean number of slugs per trap at the consecutive dates constituted: 34.2; 33.8 and

Table 1. The mean degree of damages, % of damaged rape plants above ground and % of the number of damaged rape plants within the class ranges of *D. reticulatum* intensity (slug number per trap)

Week	Characteristics	Slug number per trap				
		18–23	24–29	30–35	36–41	>41
1 week	Mean number of slugs	20.0	26.3	34.5	40.6	45.0
	Mean degree of damages	0.57	1.21	0.71	1.67	2.52
	% of damaged plants above ground	14.2	30.2	17.8	41.8	63.0
	% of damaged plants	44.0	53.3	45.7	74.4	80.0
	% of plants damaged to degree 4	0.0	14.0	5.3	18.8	43.3
2 week	Mean number of slugs	21.5	27.8	32.5	38.2	45.0
	Mean degree of damages	2.17	2.91	3.37	3.59	1.49
	% of damaged plants above ground	54.3	72.6	84.3	89.8	37.3
	% of damaged plants	95.0	100.0	100.0	100.0	100.0
	% of plants damaged to degree 4	24.0	47.5	64.3	72.0	2.7
3 week	Mean number of slugs	18.0	26.6	33.8	38.5	45.7
	Mean degree of damages	3.40	2.86	3.52	3.44	3.17
	% of damaged plants above ground	85.0	71.6	88.1	86.0	79.2
	% of damaged plants	100.0	99.2	100.0	100.0	100.0
	% of plants damaged to degree 4	64.0	42.0	66.8	67.7	58.0

34.4. Among these slugs, the percentage of large individuals (>1 cm long) was 21%, 19% and 25%, respectively.

In wheat crop, the mean degree of plant damages in the first week of observations amounted to 0.4 and ranged from 0.2 with an average of 1.8 slugs per trap to 1.2 with an average of 14 slugs per trap (Tab. 2). In the second week the degree of plant damages significantly increased to 1.9 and ranged, on average, between 1.8 and 2.3 with 4.9 and 16.7 slugs per trap, respectively. The mean percentage of all damaged plants in the first week ranged from 10.3% to 56%, whereas in the second week it ranged between 55.3% and 78.7%. However, the percentage of plants damaged to the highest degree (4) was variable and amounted, on average, to 4.8% and 41% at the successive dates. The number of caught slugs in wheat crop in the first

Table 2. The mean degree of damages, % of damaged wheat plants above ground and % of the number of damaged wheat plants within the class ranges of *D. reticulatum* intensity (slug number per trap)

Week	Characteristics	Slug number per trap				
		<4	4–6	7–9	10–12	>13
1 week	Mean number of slugs	1.8	4.8	7.8	10.0	14.0
	Mean degree of damages	0.20	0.29	0.62	0.82	1.20
	% of damaged plants above ground	5.1	7.2	15.4	20.5	30.0
	% of damaged plants	10.3	16.7	31.3	38.0	56.0
	% of plants damaged to degree 4	2.3	3.0	7.3	8.0	12.0
2 week	Mean number of slugs	–	4.9	7.8	11.0	16.7
	Mean degree of damages	–	1.83	1.82	1.88	2.32
	% of damaged plants above ground	–	45.8	45.4	47.0	58.0
	% of damaged plants	–	55.3	60.8	69.3	78.7
	% of plants damaged to degree 4	–	41.6	39.6	36.0	46.7

week of observations was, on average, 5.6 slugs per trap, about 59% of which were large slugs. In the second week, this number significantly increased to 8.3 slugs per trap (about 68% of large slugs).

Laboratory studies. When comparing the rate and degree of seedling damages caused by *D. reticulatum,* it was found that rape during the first 24 hours of slug feeding was damaged much more significantly and severely than wheat. Rape after the first day of feeding was consumed in 18.5%, while wheat – in 6.5%. After 13 days of slug feeding, rape seedlings were destroyed to 95%, whereas wheat seedlings – to 53% (critical significance level p is given in table 3).

The damage rate of rape and wheat seedlings can be presented with the use of multinomial curvilinear regression of the third and second degree, respectively (Fig. 1). The significance of the effect of elapsed time on the increase of rape and wheat seedling damages is characterized by two parameters: critical significance level p, which is less than 0.001 for the both plant species under study, and the determination coefficient R^2 taking the values of 99.7% for rape and 98.3% for wheat. The obtained curve for wheat means a slow increase of plant damages on the first days of slug feeding and a considerably more rapid plant damage increase on the following days. The increase of plant damages in rape was considerably more rapid on the first days, then was a little slower, and was again rapid afterwards during the successive days.

Studies on *D. reticulatum* feeding on wheat grain showed a marked fluctuation in the rate of seed consumption (Fig. 2). During the first four days of feeding the slugs ate more and more seeds. For example, on the third day they ate, on average, 1.3 seeds, while on the fourth day – 1.8 seeds. It may be suggested that, after four days of feeding their food requirements were satisfied, since at day 5 the slugs ate, on average, only 0.8 seeds (Fig. 2). The number of consumed wheat seeds in the period of consecutive 9 days of slug feeding systematically increased, though no correlation was found because of the observed fluctuations. The variation of seed damages caused by particular slug specimens on the consecutive days of feeding is deter-

Table 3. A comparison of the % of rape and wheat plants damages by the Student t-test

Day	Number of boxes	% of damages		p
		rape	wheat	
1	20	18.5	6.5	0.0052
2	20	29.5	10.4	0.0023
3	20	40.1	12.0	0.0001
4	20	45.3	14.4	<0.0001
5	20	52.3	19.4	<0.0001
6	20	60.3	22.3	<0.0001
7	20	64.2	25.7	<0.0001
8	20	66.6	30.8	<0.0001
9	20	70.9	32.3	<0.0001
10	20	73.5	34.0	<0.0001
11	20	80.4	37.1	<0.0001
12	20	84.1	47.8	<0.0001
13	20	94.7	52.9	<0.0001

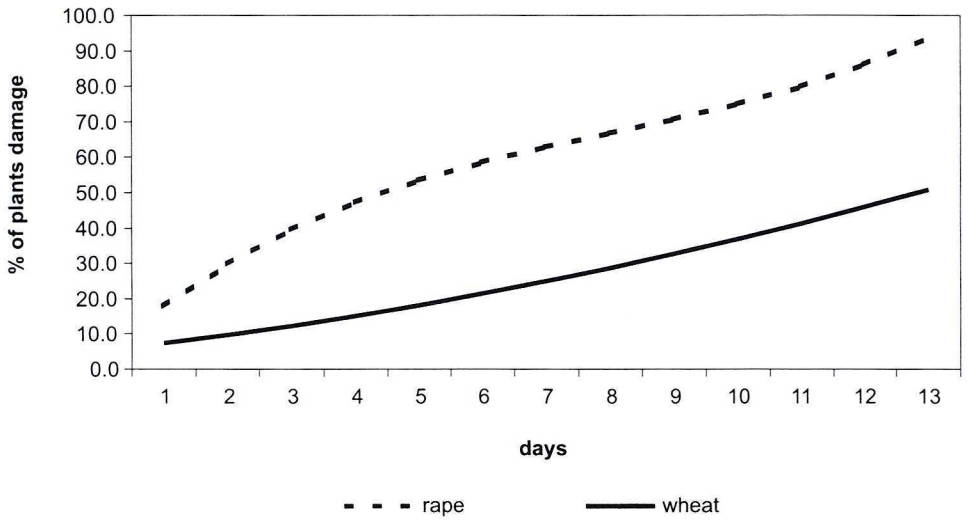

Fig. 1. The damage increase rate of rape and wheat above ground for 13 days. Curvilinear regression equations: $Y(rape)=3.44+16x-1.51x^2+0.0625x^3$ ($p<0.001$; $R^2=99.7\%$) and $Y(wheat)=5.35+1.97x+0.118x^2$ ($p<0.001$; $R^2=98.3\%$), where x is a consecutive day

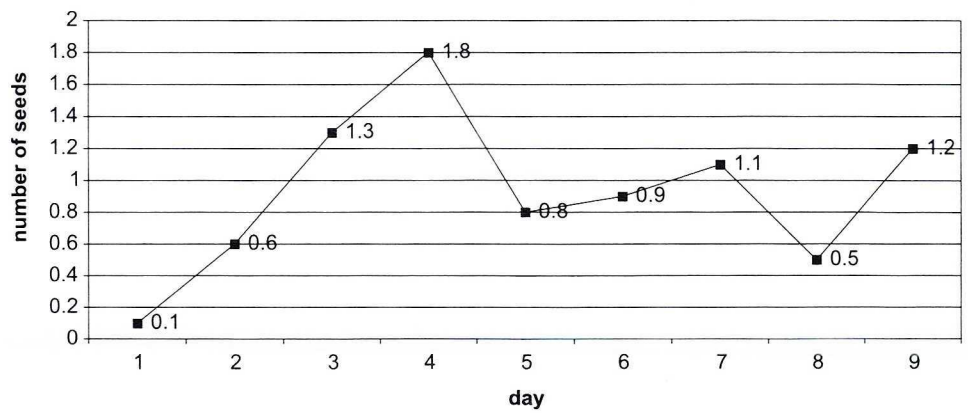

Fig. 2. Mean number of seeds consumed by *D. reticulatum* during one consecutive day

mined by the observation interval (minimal and maximal observations) and by standard deviation (Tab. 4). These data indicate that with the time of slug feeding, the variation in the number of consumed seeds becomes stable. Downward tendencies were observed in the relation of the standard deviation to the average number of eaten seeds. Generally, the average number of wheat seeds consumed by *D. reticulatum* increased on the consecutive days of slug feeding from 0.1 seed after 24 h feeding to 8.3 seeds after nine days of feeding.

Table 4. The mean number of wheat seeds consumed by *D. reticulatum* after consecutive days of feeding

Day	Number of observations	Average no. of consumed seeds	Standard deviation	Minimal observation	Maximal observation
1	10	0.1	0.32	0	1
2	10	0.7	0.68	0	2
3	10	2.0	1.70	1	6
4	10	3.8	1.99	1	7
5	10	4.6	2.37	1	8
6	10	5.5	2.51	2	9
7	10	6.6	2.27	3	9
8	10	7.1	2.03	4	10
9	10	8.3	1.57	6	10

DISCUSSION

Observations on plant damages in winter oilseed rape and winter wheat and on the intensity of *Deroceras reticulatum* occurrence began under field conditions about two weeks after seed sowing. Until that time, slugs fed on seeds in the soil as well as on rape cotyledons and on the first leaf of wheat immediately after their emergence above the soil surface. In the case of rape, the most severe plant damages fall on the period of cotyledon emergence from the ground and later – on the development of the first leaves. As shown by the laboratory studies, a single slug specimen damages 10 rape seedlings in about 95% during 13 days of its feeding. Considerably less damaged are rape seeds and seedlings below the ground surface (Moens et al. 1992; Frank 1998 a; 1998 b). In the case of wheat, a considerable part of plant damages takes place in the soil. Slugs eat seed embryos and sprouts shortly after sowing. One individual of *D. reticulatum* damages, on average, over 8 wheat seeds during nine days. After the appearance of wheat plants, slugs continue their damages on the first leaves, but to a considerably smaller degree than on rape leaves. The percentage of seedling damages in wheat is almost half lower than that in rape. As soon as wheat leaves become hard, slugs reduce their feeding and plant damages caused by them are more and more weaker (Gould 1961; Duthoit 1964; Cook et al. 1997).

In the both crops, at the first date of observations (after a two-week feeding of the field slug), a highly significant relation was found between the slug number and the degree of plant damages. The more slugs were caught in traps, the higher was the degree of plant damages. This correlation was not shown at the second and third date of observations. The reason of that was the fact that slugs moved in search of new food from the places, where the crop plants were damaged to 100% or almost to 100%.

In the rape crop, as a result of a month feeding of a numerous population of field slugs (about 34 specimens per trap) nearly 60% of plants were damaged to a highly severe degree (4). In the wheat crop, a fivefold smaller population of slugs (about 7 individuals per trap) damages over 40% of plants in about a 3-week period. This suggests that a less numerous slug population than that in rape could cause heavy plant damages in wheat crops. However, it should be taken into consideration that

the number of large slugs caught in wheat, which caused significant damages, was 40% lower than their number in rape. Besides that, wheat could be damaged to a large degree also below the ground immediately after sowing.

The size of rape and wheat damages caused by slugs depends on the size of slugs as well as on their activity determined by meteorological conditions. Small slugs (<1 cm long) caused insignificant plant damages. For this reason small individuals are usually omitted when estimating the effect of the number of feeding slugs on the size of plant damages (Frank 1998b). The number of slugs caught in baited traps on the observed oilseed rape and wheat fields was high. Nevertheless, small slugs, whose participation in plant damages was low, were dominant, especially in rape.

Generally, in the period of 3–4 weeks after sowing, slugs damaged about 60% of rape seedlings at the mean intensity of large slugs of 7.4 per trap and about 40% of wheat plants with, on average, 4.4 large slugs per trap.

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POLISH SUMMARY

OCENA USZKODZEŃ ROŚLIN I NASILENIA WYSTĘPOWANIA POMROWIKA PLAMISTEGO – *DEROCERAS RETICULATUM* (MÜLLER) W UPRAWACH RZEPAKU OZIMEGO I PSZENICY OZIMEJ

Rzepak ozimy i pszenica ozima są w ostatnich latach, głównie w południowo-zachodnich rejonach Polski, silnie uszkadzane przez ślimaka pomrowika plamistego (*Deroceras reticulatum*). Największe szkody występują w okresie bezpośrednio po siewie i po wschodach roślin. W warunkach polowych i laboratoryjnych przeprowadzono badania nad tempem i wielkością uszkodzeń siewek roślin i liczebnością ślimaków odławianych w pułapki przynęcające. Wykonano także obserwacje nad tempem uszkodzeń nasion pszenicy. Obserwacje terenowe przeprowadzono jesienią 2001 roku, w dwóch miejscowościach w południowej części województwa opolskiego.

W obu badanych uprawach, w pierwszym terminie obserwacji stwierdzono wysoce istotny związek pomiędzy liczbą ślimaków a stopniem uszkodzeń roślin. Im więcej było odłowionych ślimaków w pułapkach tym wyższy był stopień uszkodzeń roślin. Średni procent silnie uszkodzonych roślin rzepaku, cztery tygodnie po siewie roślin, wynosił prawie 60% przy średniej liczbie 7 dużych ślimaków na pułapkę. W warunkach laboratoryjnych, w ciągu 13 dni żerowania, jeden ślimak niszczył 10 siewek rzepaku w 95%. W uprawie pszenicy, po trzech tygodniach od siewu, średni procent silnie uszkodzonych roślin wynosił około 40% przy ponad 4 dużych ślimakach na pułapkę. Jeden ślimak niszczył średnio ponad 8 nasion pszenicy w ciągu 9 dni, a 10 siewek pszenicy w 53% w ciągu 13 dni.