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ASSESSING MODERN CULTIVARS OF WINTER WHEAT TO DAMAGE BY THE GREY FIELD SLUG (*DEROCERAS RETICULATUM*)

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ASSESSING MODERN CULTIVARS OF WINTER WHEAT TO DAMAGE BY THE GREY FIELD SLUG (*DEROCERAS RETICULATUM*)

by

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Abstract

Differences in the susceptibility of twelve Winter Wheat cultivars to grain hollowing by the field slug (*Deroceras reticulatum*) were tested in the laboratory. Damage was assessed after 1, 2 and 5 days exposure to slugs at 10°C. Differences were apparent between cultivars, with the most popular cultivars in recent years, Riband, Mercia and Avalon, being most severely damaged. The cultivars Buster, Hunter, Parade, Hussar and Brigadier suffered significantly less damage than Riband, Mercia and Avalon. The damage to grain could be related to sugar content in the ungerminated seed and release of sugars and other solutes during germination at both extremes of slug damage to Winter Wheat cultivars.

These results suggest that it may be possible to assess the risk of damage to Winter Wheat cultivars based on the mobilisation and release of sugars in germinating seeds. Perceived differences in slug damage to particular cultivars needs to assessed under field conditions in conjunction with more refined assessments of sugar content in order to substantiate this relationship.

1. Objectives

The objectives of this project were to determine the susceptibility to slug attack of cultivars of Winter Wheat on the Recommended and Provisionally Recommended lists, and to ascertain whether a simple measure such as water soluble sugar content of the seed is a reliable indicator of risk to slug attack.

2. Introduction

Slug damage to cereals, especially Winter Wheat has begun to increase again in the last few years after the increase in set-aside and other changes in agronomic practice. Despite the plethora of molluscidal products currently available for slug control, and the knowledge gained from previous HGCA-funded work on cultural methods for reducing slug problems (Glen & Wiltshire, 1992; Spaull & Davies, 1992), slugs are still a major problem to many growers of Winter Wheat.

Previous work, funded by the HGCA, demonstrated differences in the degree of grain hollowing of Winter Wheat cultivars by the grey field slug (*Deroceras reticulatum*) in the

laboratory (Spaull & Eldon, 1990). Differences in damage were suggested to be due to the rate of release of water soluble sugars and other solutes by the seed. The cultivars tested in 1990 by Spaull & Eldon are nearly all outclassed now, apart from one (Mercia), which is still on the 1995 Fully Recommended List.

This work needed to be repeated using cultivars on the current Fully and Provisionally Recommended list to determine whether varietal susceptibilty to grazing by the grey field slug is present in modern Winter Wheat cultivars, and whether susceptibility can be related to the sugar content and rate of leaching of water soluble sugars by seed.

3. Materials and Methods

3.1 Assessment of slug damage to grain

Adult slugs (*D. reticulatum*) were obtained from field populations by trapping with a bait of grain and bran. The slugs were kept on a diet of lettuce for a week after collection at 10 °C before being used in any experiments. Adult slugs were starved for 24h before use in feeding tests on Winter Wheat grain.

Untreated seed of twelve cultivars of Winter Wheat were used, seven of which are on the 1995 Fully Recommended List (cvs. Brigadier, Hereward, Hunter, Hussar, Mercia, Riband and Spark), two from the Provisionally Recommended List (cvs. Buster and Dynamo), two cultivars which were the most susceptible (cv. Avalon) and resistant (cv. Parade) to slug damage in Spaull & Eldon's previous work (1990), and cv. Zodiac which is a cv. Parade cross. The cultivars Buster and Dynamo are also Parade crosses.

The protocol of Spaull & Eldon (1990) was followed where four seeds were placed on well-moistened filter paper equidistant from each other and the edge of a 9cm diameter petri-dish. A single adult grey field slug was placed in the centre of the dish, and kept in an incubator at 10°C. Ten replicates were used for each cultivar, and grain hollowing was assessed after 1, 2 and 5 days. Grain hollowing was scored as a crude percentage of individual seeds.

3.2 Assessment of sugar content in seed

The water-soluble carbohydrate content of non-germinated seed was determined using the methods of Spaull & Eldon (1990). Two hundred seeds (approx. 10g) were boiled in 25 ml distilled water for three minutes, macerated and centrifuged at 4000 g for three

minutes. The supernatant was tested for total water-soluble sugar content using a Boehringer-Mannheim test kit, and expressed as glucose equivalents.

3.3 Assessment of electrical conductivity of germinating seed

The electrical conductivity of seed (a crude estimate of leaching of electrolytes) was undertaken from a dish containing 200 seeds (10g fresh weight) on saturated filter paper after 1, 2 and 3 days at 10°C. The conductivity was measured using a conductivity meter, and results expressed as electrical conductivity (μS)/g of seed.

4. Results

4.1 Assessment of slug damage to grain

Differences in slug damage between cultivars were apparent after 1 day (Fig. 1a); cvs. Parade, Dynamo, Hunter and Buster had been grazed significantly less than Riband, Mercia and Avalon. Over the next four days, grain hollowing increased on all cultivars until the experiments were terminated on Day 5 (Figs. 1b-c). After 5 days, Buster was the least damaged cultivar, with 18% of grain hollowed, compared to Riband which had a mean score of 42% grain hollowed (Fig. 1c). There was very little difference between the cultivars Buster, Hunter, Parade, Hussar and Brigadier (18-21%), but these cultivars were all significantly less grazed than Riband, Mercia and Avalon (all greater than 40% grain hollowing). The remaining cultivars had had grain hollowed by 25-35%.

4.2 Sugar content in seed

The results from the assessment of total water-soluble sugar content are shown in Table 1. The cultivars Parade, Buster and Hunter had the lowest sugar content, and were also the three least damaged cultivars in the slug feeding experiments (Fig. 1). The greatest sugar content was in the cultivars Riband, Mercia and Hereward, which were among the most damaged cultivars in the slug grazing experiments.

4.3 Electrical conductivity of germinating seed

The measurements of electrical conductivity differed between cultivars after 1 day (Table 2), but the differences became less marked after 2-3 days. The lowest conductivity measurements after 1 day were obtained from the cultivars Buster, Hussar, Spark, Mercia and Parade (all < 10 μS), and these were also among the cultivars with the lowest conductivity after 3 days. The highest measurements after 1 day were obtained from Dynamo, Riband and Avalon.

Table 1. Total water-soluble sugar content of twelve cultivars of Winter Wheat (glucose equivalents) and ranking of slug damage (1-12, where 1 is least and 12 is most damage)

Cultivar	**Sugar content (g/l x 10^{-2})**	**Damage ranking**
Parade	0.7	3
Buster	1.3	1
Hunter	1.6	2
Hussar	2.2	4
Zodiac	3.5	8
Spark	3.8	6
Dynamo	4.1	7
Avalon	4.7	10
Brigadier	4.9	5
Hereward	5.6	9
Mercia	6.1	11
Riband	6.2	12

5. Discussion

The results obtained from these experiments confirm some of the earlier findings of Spaull & Eldon (1990); particularly the relative tolerance of the cultivar Parade to slug damage and the susceptibility to damage of the cultivar Avalon. The hypothesis proposed by Spaull & Eldon

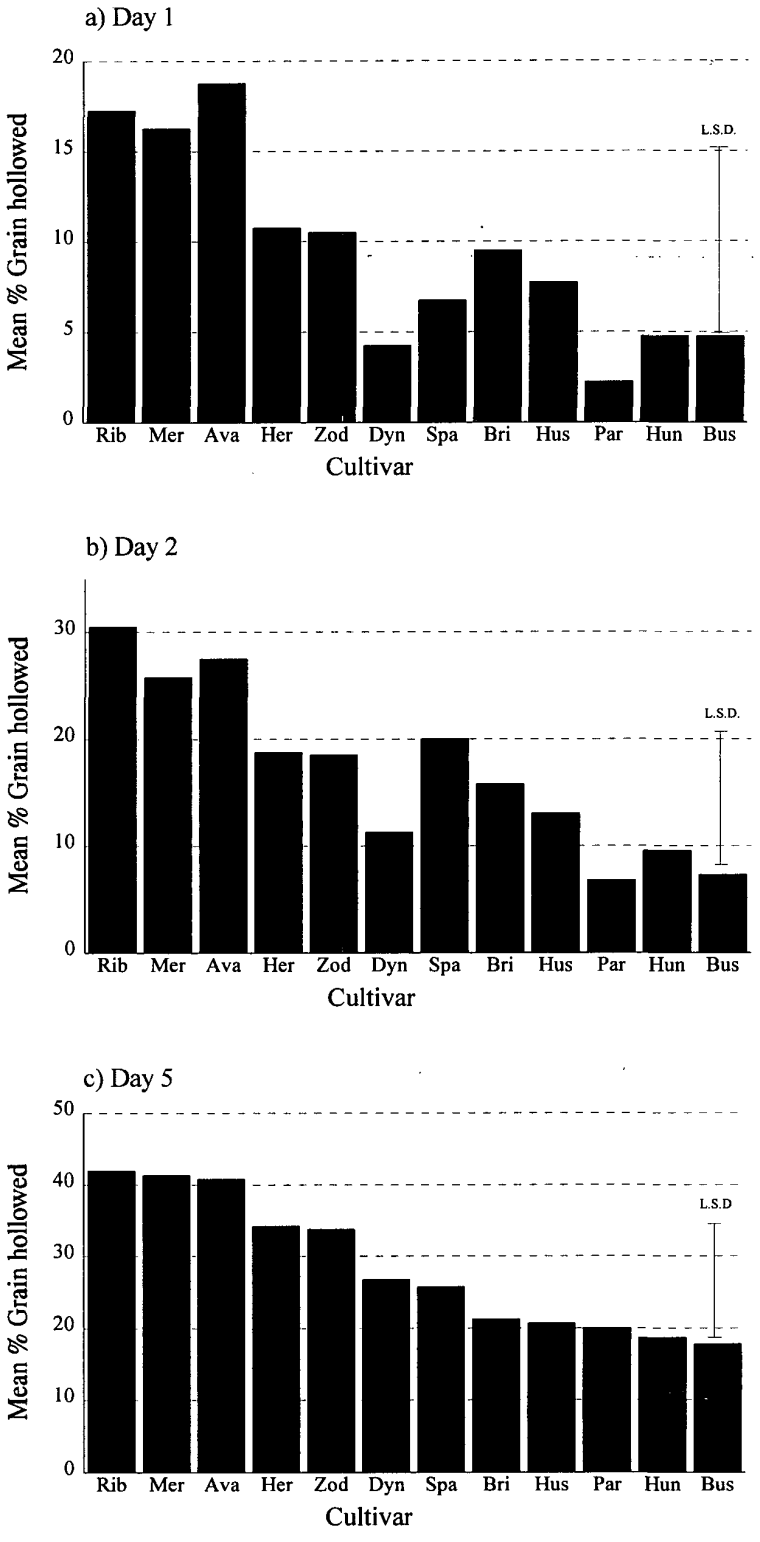

Fig. 1. Percentage grain hollowed by *Deroceras reticulatum*.
L.S.D = Least Significant Difference (P = 0.05)

(1990), that the exudation of sugar solutes during the early stages of seed germination makes the seed more attrcative to slugs, is to some extent upheld based on many of the results obtained during this study.

Table 2. Electrical conductivity (μS) of leachate from 12 Winter Wheat cultivars (expressed per g of seed)

Cultivar	Day 1	Day 2	Day 3
Avalon	12.6	17.4	23.8
Brigadier	11.4	19.6	26.2
Buster	8.4	15.1	19.8
Dynamo	14.2	20.2	24.3
Hereward	12.3	17.2	22.3
Hunter	10.1	13.6	18.6
Hussar	8.4	14.4	19.7
Mercia	9.6	12.2	18.8
Parade	9.4	13.1	16.8
Riband	13.8	20.6	27.2
Spark	8.8	12.6	18.6
Zodiac	11.2	17.9	23.7

The four cultivars with the lowest sugar content prior to germination (Parade, Buster, Hunter and Hussar) were also the four cultivars that were least damaged in the slug grazing experiments. The opposite is also true to some extent; cultivars Riband, Mercia, Hereward and Avalon had high sugar content in the seed, as well as being most heavily grazed by slugs.

The rate of mobilisation of sugars by seed, as measured by the change in the electrical conductivity of the leachates from germinating seed, suggests that cultivars that rapidly begin production of sugars, are more prone to being damaged by slugs. Rapid sugar producers such as Riband and Avalon suffered the heaviest grazing by slugs within the first 2 days of the feeding experiments. Slower sugar producers such as Parade and Hunter suffered lower damage from slugs.

This hypothesis of 'high seed sugar content and rapid rate of sugar production' does not explain some of the variability in results obtained from cultivars such as Zodiac (low

sugar, high grazing), Brigadier (high sugar in seed and rate of production, low-moderate grazing) and Spark (moderate sugar content, low rate of sugar production, moderate grazing). However the hypothesis fits well at the extreme ends of the spectrum, namely low slug grazing when sugar content in seed is low and sugar production less rapid (cvs. Buster, Hunter, Parade and Hussar), and high sugar content in seed, high degree of slug grazing and rapid production of sugars (cvs. Riband, Avalon, Hereward and Mercia).
If a threshold of 4.5g/l x 10^{-2} (total sugars) and/or 22μS/g seed (electrical conductivity) is applied, the risk of damage to 25% of the grain would have been correctly predicted for all but two of the cultivars tested (Brigadier and Dynamo).
The possibility of a genetic link in resistance to slug attack has been hinted at with Buster, whose Pedigree is Parade. However the other cultivars with a Parade pedigree, Dynamo and Zodiac, did not show any degree of resistance to slug damage.
There does appear to be a link between sugars in the seed and its production, and the degree of grazing by slugs under laboratory conditions. The method used to measure production of sugars in the leachate (electrical conductivity) is admittedly a rather crude measure, as it does not distinguish between other electrolytes being produced by the seed which may or may not have an influence on the feeding behaviour of slugs. There are many other variables which may affect these results such as provenance of the seed, age of seed, physiological state of the slugs used in the experiment etc.., however it has been shown that under laboratory conditions at least, it is possible to correlate the likelihood of damage to seed by slugs with a relatively simple measurement such as seed sugar content and electrical conductivity of leachates from germinating seeds. The situation is of course different under field conditions, where seeds may not germinate synchronously, there are fluctuations in temperature, moisture, seed has been treated with fungicidal seed treatment, and the behaviour of the slugs will vary due to different ages, species and hunger.
This work needs to be extended to include controlled field conditions in order to determine whether the susceptibilities of Winter Wheat cultivars to slugs seen in the laboratory, is similar under more natural conditions. Further laboratory studies should also be undertaken using more sophisticated measurements of the production of sugars in germinating seed, perhaps by identfying the production of specific sugars during the early stages of germination.
It is interesting to note that in these laboratory tests, the cultivars that were most severly grazed by slugs, namely Riband, Mercia and Avalon, have been the most popular cultivars of Winter Wheat grown in the UK in recent years.

6. Conclusions

This short project has confirmed the earlier observations by Spaull & Eldon (1990) that susceptibilty of Winter Wheat cultivars to grain hollowing by the grey field slug (*Deroceras reticulatum*) can be related to the sugar content in the seed and leaching of solutes during the early stages of germination.
Further work is necessary to determine whether this relationship can be strengthened using a more refined measure of sugar content in germinating seed, and whether this relationship also holds up under natural field conditions under different levels of slug grazing.

7. References

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