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## Autumn survey of wheat bulb fly incidence 2017


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# CONTENTS

# 1. Abstract

All cereals, except oats, can be attacked by wheat bulb fly (WBF). Eggs are laid in late summer in bare soil following fallows or early harvested crops, such as vining peas, particularly if fields are cultivated between mid-July and mid-August. Fields cropped with root crops, such as sugar beet, potatoes and onions, are also favoured as egg-laying sites, as the pest can access bare soil between the rows. WBF is most prevalent in eastern England and north-eastern England. Egg numbers can be estimated by soil sampling and related to threshold levels of 250 eggs/m$^2$ (2.5 million eggs/ha) for crops sown in September and October or 100 eggs/m$^2$ (1.0 million eggs/ha) for crops sown from November onwards.

The specific objectives of the project are:

1. To measure the incidence of WBF each autumn in the infested areas
2. To forecast the need for seed treatment

A total of 30 fields were sampled in September 2017 in areas prone to WBF, with 15 in eastern England and 15 in northern England. The sites were chosen to represent some of the main preceding crops, leading to a risk of wheat bulb fly damage in each area.

In autumn 2017, none of the sampled fields was considered at high risk (egg numbers 250-500/m$^2$) or very high risk (egg numbers >500/m$^2$), five fields (17%) were considered at moderate risk, containing egg numbers between 100/m$^2$ and 249/m$^2$ and 25 fields (83%) were considered at low risk, containing egg numbers less than 100/m$^2$.

No fields were above the 250 eggs/m$^2$ threshold. Based on this threshold, which has been used historically as an indicator of risk, 2017 can be viewed as having the lowest overall risk since monitoring began in 1984. It is possible that, as relatively good progress was made with the winter wheat harvest in 2017, there was less time for saprophytic fungi to develop in cereal ears, which, in turn, meant less food for adult WBF females and as a result they produced less eggs than in a season when their fungal food source is more plentiful. Average egg numbers in the North were slightly higher than in the East, with 55 eggs/m$^2$ in the East and 67 eggs/m$^2$ in the North. Over all sites, the highest risk was after potatoes, with a mean of 99 eggs/m$^2$. The next highest risk was after onions, with 62 eggs/m$^2$ (although only one site was sampled).

Late-sown (November onwards) or slow developing crops are at greater risk from WBF than those that are early sown (September/October), due to slower tiller development. As a result, a lower threshold of 100 eggs/m$^2$ or 1 million eggs/ha is applicable for these crops. In the north of England 27% of sites were above this level but only 7% were above this level in the East. All fields in the moderate category and would benefit from a seed treatment if sown from November onwards.

## 2. Introduction

All cereals except oats can be attacked by wheat bulb fly (WBF). Eggs are laid in late summer in bare soil following fallows or early harvested crops, such as vining peas, particularly if fields are cultivated between mid-July and mid-August. Fields cropped with root crops, such as sugar beet, potatoes and onions, are also favoured as egg-laying sites, as the pest is able to access bare soil between the rows (AHDB, 2016). The pest is most prevalent in eastern England and north-eastern England. In outbreak years, widespread damage can occur.

Eggs are laid in late July and August in England and up to mid-September in Scotland and remain dormant throughout late autumn and early winter. The larvae hatch between January and March. Soon after hatching, they invade shoots of cereal crops and the attacked shoots wither or become yellow and stunted. These symptoms are known as 'deadhearts'.

The level of risk each year fluctuates greatly, due mainly to July and August rainfall (Young & Cochrane, 1993) and the harvest dates of the previous wheat crops. The longer crops remain in the ground, the longer adult flies have to feed on saprophytic fungi within the cereal ears and mature their eggs. Incidence generally increases following a wet harvest period, such as in 2004, and is lowest after a hot, dry summer, such as in 1995. The proportion of fields having an egg count greater than the 250 eggs/m² threshold ranged from 3% to 44% in the period 1984–1999 (Oakley & Young, 2000) and from 3% to 50% between 2000 and 2016 (Figure 1).

The start of the 2017 wheat harvest was in line with the five-year average. Winter wheat harvest started at the beginning of August and good progress was made throughout the month despite very unsettled weather. About 90% of the winter wheat crop had been harvested by the first week of September, which was marginally ahead of the five-year average. This suggests that the risk from wheat bulb fly may be low again, as per last year, and this survey will help determine if this is the case and provide valuable information on the potential risk from the pest for the 2017/18 season.

The overall objective of the project is to establish the annual incidence of wheat bulb fly in the autumn to allow farmers to decide on the need for seed treatment in late-sown crops. Specific objectives are:

1. To measure the incidence of WBF each autumn in the infested areas.
2. To forecast the need for seed treatment.

Egg numbers can be estimated by soil sampling and related to threshold levels of 250 eggs/m² (2.5 million eggs/ha) for crops sown in September or October or 100 eggs/m² (1.0 million eggs/ha) for crops sown from November onwards. At lower infestation levels, economic damage is less likely, although winter cereal crops sown from November onwards or those sown in spring before the end of March can be particularly vulnerable. Larvae attack shoots of wheat, barley and rye from January to April, with yield loss depending on tiller density at the time of attack. Crops still at the single shoot stage in February are most vulnerable and may be completely destroyed (Young, 2000). Yield losses of up to about 4t/ha have been recorded following severe damage (Young & Ellis, 1996).

The options for control of WBF have been reduced by pesticide reviews and withdrawals and are currently limited to a tefluthrin + fludioxinil seed treatment (Austral Plus) and a cypermethrin seed treatment (Signal 300 ES). In 2016, uses of chlorpyrifos-ethyl or products containing chlorpyrifos-ethyl were lost due to a non-dietary risk review of current uses, as a result of the reduction of the toxicological reference values recommended by EFSA. Consequently, chlorpyrifos can no longer be used as an egg hatch spray against wheat bulb fly larvae.

Seed treatment is the most effective option for late-sown crops, for example those at risk following potatoes, sugar beet, onions or red beet. Young (1992) demonstrated that November and December drillings of winter wheat were more vulnerable to WBF damage than earlier sowings and are, therefore, more likely to benefit from the use of a preventive insecticidal seed treatment.

## 3. Materials and methods

A total of 30 fields were sampled in September 2017 in areas prone to WBF, with 15 in eastern England and 15 in northern England (Table 1). The survey was stratified to represent some of the main preceding crops (Table 2) leading to a risk of wheat bulb fly damage in each area.

For each field sampled, 32 cores each of 7.2 cm diameter or 20 cores each of 10 cm diameter were taken to cultivation depth. Fields were sampled in a standard W sampling pattern. WBF eggs were extracted following soil washing and flotation in saturated magnesium sulphate. Egg numbers were expressed as number of eggs per $m^2$.

**Table 1.** Location of sampling sites, by region and county.

| Region | County | Number of fields sampled |
|---|---|---|
| Eastern England | Cambridgeshire | 5 |
| | Norfolk | 8 |
| | Suffolk | 2 |
| | Total | 15 |
| Northern England | East Yorkshire | 11 |
| | North Yorkshire | 4 |
| | Total | 15 |

**Table 2.** Preceding crop for sampled fields.

| Preceding crop | Eastern England | Northern England |
|---|---|---|
| Onions | 1 | 0 |
| Peas (vining) | 1 | 8 |
| Potatoes | 3 | 7 |
| Spring beans | 1 | 0 |
| Sugar beet | 9 | 0 |
| Total | 15 | 15 |

## 4. Results

In autumn 2017, none of the 30 surveyed fields was considered at very high risk (egg numbers>500/m$^2$) or at high risk (egg numbers between 250/m$^2$ and 500/m$^2$). A total of five fields (17%) were considered at moderate risk, containing egg numbers between 100/m$^2$ and 249/m$^2$ and 25 fields (83%) were considered at low risk, containing egg numbers less than 100/m$^2$. None of the fields sampled were above the 250 eggs/m$^2$ threshold (Figure 1). The overall risk in 2017 is the lowest recorded since monitoring began in 1984. It is possible that, as the winter wheat harvest was ahead of that in 2015, there was less time for saprophytic fungi to develop in cereal ears, which in turn meant less food for adult WBF females. As a result, they produced less eggs than in a season when their fungal food source is more plentiful.

Average egg numbers in the north of England were 67/m$^2$ which is higher than in the east of England, where 55/m$^2$ were recorded. Over all sites, the highest risk was after potatoes (Figure 2), with a mean of 99 eggs/m$^2$. The next highest risk was after onions, with 62 eggs/m$^2$, although only one site was sampled.

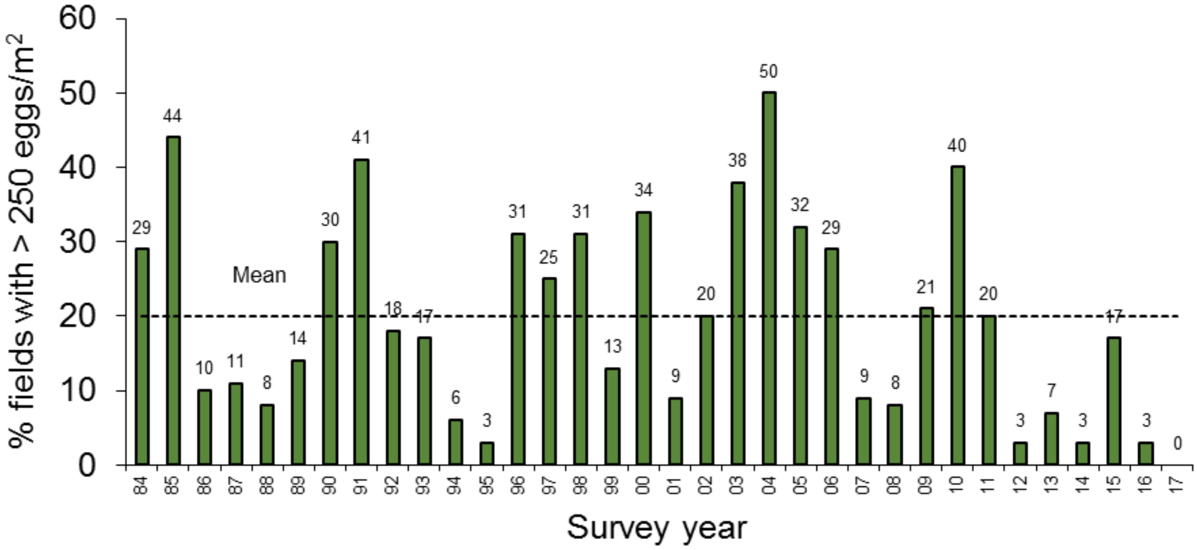


**Figure 1.** Wheat bulb fly annual risk levels 1984–2017 and overall mean (dashed line). Fields at risk have >250 eggs/m²

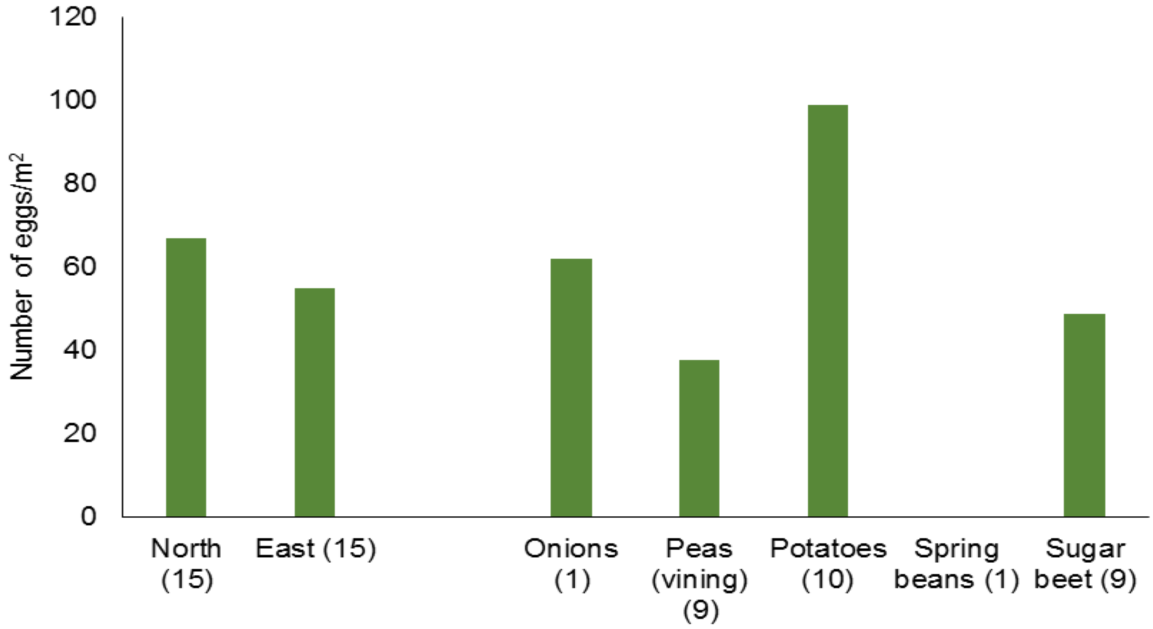


**Figure 2.** Average egg counts by region and previous crop in autumn 2017 (number of sites in brackets).

## 4.1. Eastern England

The mean egg number was 55 eggs/m² for sites sampled in eastern England. This is higher than in 2014 (46 eggs/m²) but lower than 2013 (76 eggs/m²) and 2016 (90 eggs/m²) and much lower than the 179 eggs/m² and 309 eggs/m² recorded in 2011 and 2010, respectively. Therefore, the potential for WBF damage in eastern England is low. However, late-sown crops, which are likely to have few tillers at the time of egg hatch, could still be at risk. The highest egg population of 185 eggs/m² was after potatoes in Norfolk. In total 14 of the 15 sites sampled had egg numbers lower than 100 eggs/$m^2$. Potatoes had the highest mean number of eggs of all crops sampled (110 eggs/$m^2$, Table 3). A total of three potato fields were sampled.

**Table 3.** Mean eggs/m² and preceding crops in eastern England in autumn 2017 (range in brackets).

| Preceding crop | Number of fields sampled | Mean number of eggs per m² |
|---|---|---|
| Onions | 1 | 62 |
| Peas (vining) | 1 | 0 |
| Potatoes | 3 | 110 |
| Spring beans | 1 | 0 |
| Sugar beet | 9 | 49 |
| Mean egg count | | 55 (0–185) |

In eastern England, none of the sampled fields were in the very high risk or high risk categories (Table 4). Overall, only 7% of the fields sampled (1/15) contained egg populations in the moderate, high or very high risk categories. This is the lowest level of infestation recorded since 2009.

**Table 4.** Infestation categories and preceding crops in eastern England in autumn 2017.

| Preceding crop | Number of fields by rotation and risk category | | | |
|---|---|---|---|---|
| | Low (<100 eggs/m²) | Moderate (100–249 eggs/m²) | High (250–499 eggs/m²) | Very high (>500 eggs/m²) |
| Onions | 1 | 0 | 0 | 0 |
| Peas (vining) | 1 | 0 | 0 | 0 |
| Potatoes | 2 | 1 | 0 | 0 |
| Spring beans | 1 | 0 | 0 | 0 |
| Sugar beet | 9 | 0 | 0 | 0 |
| Total | 14 | 1 | 0 | 0 |
| % of fields by infestation category | 93 | 7 | 0 | 0 |

## 4.2. Northern England

The mean egg number was 67 eggs/m² for northern England. This is lower than in all of the last six years (2016 89 eggs/$m^2$, 2015 168 eggs/$m^2$, 2014 125 eggs/$m^2$, 2013 129 eggs/$m^2$, 2012 79 eggs/$m^2$, 2011 161 eggs/$m^2$). The highest egg population of 142 eggs/m² was recorded in East Yorkshire after potatoes.

**Table 5.** Numbers of eggs/m² and preceding crops in northern England in autumn 2017 (range in brackets).

| Preceding crop | Number of fields sampled | Mean number of eggs per m² |
|---|---|---|
| Peas (vining) | 8 | 43 |
| Potatoes | 7 | 94 |
| Mean egg count | | 67 (0–142) |

In northern England as in eastern England, none of the fields were in the very high or high risk categories, four (27%) were in the moderate category and 11 (73%) were in the low category (Table 6). Overall, four fields (27%) were in risk categories of moderate or above, which is the equal lowest recorded since 2009 (2016: 27%, 2015: 87%, 2014: 53%, 2013: 40%, 2012: 27%, 2011: 60%, 2010: 60% and 2009: 47%). This represents a relatively low risk to crops sown after November.

**Table 6. Infestation categories and preceding crops in northern England in autumn 2017.**

| Preceding crop | Number of fields by rotation and infestation category | | | |
|---|---|---|---|---|
| | Low (0–100 eggs/m²) | Moderate (100–250 eggs/m²) | High (250–500 eggs/m²) | Very high (>500 eggs/m²) |
| Peas (vining) | 7 | 1 | 0 | 0 |
| Potatoes | 4 | 3 | 0 | 0 |
| Total | 11 | 4 | 0 | 0 |
| % of fields by infestation category | 73 | 27 | 0 | |

## 5. Discussion

Egg populations above 250 eggs/m² present a risk of economic damage to winter wheat crops drilled in September and October. Egg numbers above 100 eggs/m² justify the use of seed treatment on the late-drilled crops of winter wheat or barley sown from November onwards.

### 5.1. Early sown crops (September/October)

In 2017, none of the fields sampled were over the 250 eggs/m$^2$ threshold (2.5 million eggs/ha) for crops sown in September or October. The overall risk in 2017 is the lowest recorded since monitoring began in 1984. It is possible that this is due to a low level of saprophytic fungi in the wheat ears. As these fungi provide food for wheat bulb fly adults this might help to explain the low egg numbers in 2017. The levels of fungi in the wheat ears is likely to be influenced by whether the harvest was early or late. If wet weather delays the harvest, this would provide the environmental conditions and the time necessary for the development of fungi. A very early start was made to the harvest of crops in 2017 and good progress was made during August, such that 90% of the winter wheat crop had been harvested by the first week of September, which was marginally ahead of the five-year average.

Mean egg numbers in the North were slightly higher than in the East, with 67 eggs/m$^2$ in the North and 55 eggs/m$^2$ in the East.

### 5.2. Late-sown crops (November onwards)

Late-sown (November onwards) or slow developing crops are at greater risk than those that are early sown (September/October) due to slower tiller development. As a result, a lower threshold of 100 eggs/m$^2$ or 1 million eggs/ha is applicable for these crops. In the north of England, 27% of monitored fields (four fields) were above this level but in the East only 7% of fields were above this level. All fields in the moderate infestation category would benefit from a seed treatment if sown after November.

A summary of control strategies for wheat bulb fly in relation to egg numbers and sowing date is given in Table 7.

**Table 7.** Wheat bulb fly egg numbers that would justify a seed treatment in crops sown between September and March.

| Risk category | Sowing date | | |
|---|---|---|---|
| | Sep–Oct | Nov–Dec | Jan–Mar |
| Low (<100 eggs/m$^2$) | Economic damage unlikely; no treatment | Economic damage unlikely; no treatment | Seed treatment |
| Moderate (100–249 eggs/m$^2$) | Economic damage unlikely; no treatment | Seed treatment | Seed treatment |
| High (250–500 eggs/m$^2$) | No available treatment | Seed treatment | Seed treatment |
| Very high (>500 eggs/m$^2$) | No available treatment | Seed treatment | Seed treatment |

### 5.3. Chemical control

Seed treatment (tefluthrin + fludioxinil, Austral Plus or Cypermethrin, Signal 300 ES) is effective on late-sown crops (November onwards) and is the recommended treatment for late autumn or winter sowings of wheat and barley made before the end of egg hatch in areas and rotations at risk from wheat bulb fly. Treated seed should be drilled at a recommended maximum depth of 4cm in a firm, even seedbed. It is important to note that seed treatments may not be sufficiently persistent to fully protect crops sown in September or October.

If plants are well-tillered by the time that WBF larvae hatch between January and March, it is possible that they will be able to tolerate some pest attack.

### 5.4. Non-chemical control

With the loss of chlorpyrifos egg hatch sprays, non-chemical control of WBF is likely to become increasingly important, particularly for those crops sown before November for which seed treatments will have limited efficacy.

Parasites and predators can have an impact on numbers of WBF eggs and larvae. Ground beetles and their larvae are the main predators of WBF eggs and the larvae may be parasitised by small rove beetles (Staphylinidae), particularly *Aleochara bipustulata*. Levels of up to 50% parasitism have been recorded. Rational insecticide could therefore help to protect these beneficial species, which in turn could contribute to natural control of wheat bulb fly eggs and young larvae.

The impact of WBF can be reduced by sowing early and increasing the seed rate. This is likely to result in a more robust crop which is well tillered before the start of WBF egg hatch and so can tolerate and compensate for larval invasion.

Taking account of crop tolerance is fundamental to improving pest risk assessment and achieving a rational approach to pesticide use which is cost effective and minimises the impact on the environment and the potential for the development of resistance (Ellis *et al*., 2009). This approach is the subject of an AHDB Cereals & Oilseeds funded project entitled 'Crop management guidelines for minimising wheat yield losses from wheat bulb fly' (RD 2140047118). The main aim of this project is to develop crop management guidelines that enable farmers to minimise the risk of wheat yield losses from WBF i) estimating the minimum seed rate, latest sowing date and use of seed treatment that will be required to tolerate WBF pressure and ii) estimating the threshold egg or adult WBF numbers that justify insecticide treatment for crops with different tolerances to damage. A supplementary aim is to try to improve current monitoring methods for WBF so that the risk of attack can be determined as early as possible to help make decisions on the need for insecticide seed treatments. In the absence of chlorpyrifos, the project will enable farmers and agronomists to determine the minimum seed rate and latest sowing date combinations, and the need for seed treatment, to minimise the risk of yield losses to WBF based on numbers of eggs or adults of the pest, egg viability and crop tolerance. Crop tolerance will be measurable in terms of the number of excess shoots produced by individual crops. In general, the project will significantly improve understanding of the relationship between WBF and crop yield. This in turn will help to develop IPM strategies for this pest which minimise reliance on chemical control.

Young and Cochrane (1993) showed that WBF egg numbers were negatively correlated with departure from average July temperatures and positively correlated with August rainfall. This is in line with suggestion that egg numbers are likely to be higher in years when harvest is late rather than early. A model was proposed to help predict WBF egg laying. This model has rarely been used and yet might provide a useful early warning of wheat bulb fly risk ahead of monitoring exercises aimed at counting numbers of eggs or adults. The model could be validated using the existing WBF data set collated over 13 years of AHDB funded monitoring of the pest. An effective model would help to improve the precision and timeliness of risk assessment and together with the revised threshold scheme being developed in project RD 2140047118, go some way towards an IPM strategy for WBF.

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## Appendix A

### Egg populations ranked in descending order for 15 fields sampled in eastern England in autumn 2017

| County | Previous crop | Number of eggs (number/m$^2$) | Risk category |
|---|---|---|---|
| Norfolk | Potatoes | 185 | Moderate |
| Cambridgeshire | Sugar beet | 82 | Low |
| Suffolk | Sugar beet | 75 | Low |
| Suffolk | Sugar beet | 75 | Low |
| Cambridgeshire | Potatoes | 69 | Low |
| Norfolk | Onions | 62 | Low |
| Norfolk | Sugar beet | 55 | Low |
| Cambridgeshire | Sugar beet | 48 | Low |
| Norfolk | Sugar beet | 48 | Low |
| Cambridgeshire | Sugar beet | 41 | Low |
| Norfolk | Sugar beet | 41 | Low |
| Cambridgeshire | Sugar beet | 27 | Low |
| Norfolk | Sugar beet | 21 | Low |
| Cambridgeshire | Vining peas | 0 | Low |
| Norfolk | Spring beans | 0 | Low |
| Mean | | 55 | |

## Appendix B

## Egg populations ranked in descending order for 15 fields sampled in northern England in autumn 2017

| County | Previous crop | Number of eggs (number/m$^2$) | Risk category |
|---|---|---|---|
| East Yorkshire | Potatoes | 142 | Moderate |
| East Yorkshire | Vining peas | 111 | Moderate |
| North Yorkshire | Potatoes | 111 | Moderate |
| North Yorkshire | Potatoes | 105 | Moderate |
| East Yorkshire | Potatoes | 93 | Low |
| North Yorkshire | Potatoes | 86 | Low |
| East Yorkshire | Potatoes | 68 | Low |
| East Yorkshire | Potatoes | 56 | Low |
| East Yorkshire | Vining peas | 56 | Low |
| East Yorkshire | Vining peas | 37 | Low |
| East Yorkshire | Vining peas | 37 | Low |
| East Yorkshire | Vining peas | 37 | Low |
| East Yorkshire | Vining peas | 31 | Low |
| North Yorkshire | Vining peas | 31 | Low |
| East Yorkshire | Vining peas | 0 | Low |
| Mean | | 67 | |