The agronomic consequences of Metaldehyde being removed from the UK market

BASIS Project 2013 -2014

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Contents

1. Abstract

On the 2nd of November 2012 Louise Impey reported in the farmers weekly that Metaldehyde concentrations in UK watercourses have been recorded at levels 40 times higher than EU standards recommend. "Get Pelletwise" was set up as a campaign to promote responsible use of Metaldehyde by the Metaldehyde stewardship group. The Metaldehyde stewardship group was set up in 2009 when unacceptable levels of Metaldehyde were found in water catchments used for drinking water to promote responsible usage of metaldehyde and to try to protect Metaldehyde from being removed from the market. The years following 2009 the levels of Metaldehyde in drinking water has been steadily declining until 2012 where adverse weather conditions lead to increased levels being found in water catchments. In 2012 Metaldehyde levels were found to be 4ppb in water used for drinking pre processing with chlorine etc often referred to as raw drinking water. 4 ppb is 40 times the amount recommended by EU legislation which is 0.1ppb. This has brought wide spread fear that Metaldehide could be removed from the market. Although this is of a high level when compared to the 0.1ppb standard set out by EU legislation it is important to know where the 0.1ppb figure comes from. The figure of 0.1ppb does not come from any health or environmental impact but from a near zero value generated by the EU which applies to all pesticides in drinking water.

Metaldehyde is communally used in slug pellets due to its efficacy and low cost. There are other actives used in slug pellets mainly Methiocarb and Ferric phosphate but these have a higher price per ha than Metaldehyde. Other control methods include the use of nematodes in products such as "Nemaslug" where the nematodes attack the slug and most importantly cultural control. Although Cultural control gives good control of slug populations circumstances do occur where additional control is required.

This project looks at the efficacy of the three main actives found in slug pellets today and how the removal of Metaldehide could affect slug control in the future. This was achieved by carrying out field experiments monitoring slug damage in fields treated with slug pellets and a scaled down experiment where dose rates could be assessed. Complementing this, current legislation, codes of practice and environmental considerations were discussed in order to establish accurate conclusions.

2 Literature review

2.1 The cost of Slug damage to the UK

The cost of slug damage to winter wheat is estimated to be between £2 and £3 million per year. One slug can be responsible for damaging up to 50 seeds in the first week after sowing (Bulmer 2009). Slug damage is a greater problem in heavy clay and loam soils where a cloddy seedbed has been formed. This is because there are plenty of places for slugs to shelter from the elements and breed, open seedbeds are also easier for slugs to move through when compared to a fine seedbed.

2.2 The origins of metaldehyde

Metaldehyde was originally formulated as a solid fuel for camping stoves but was discovered to have molluscicidal properties in 1928 when farmers in South Africa found dead slugs around areas in which had been used by campers (Gimingham 1940). The use of metaldehyde as a control of gastropods was first publicly documented in the UK amateur gardening press, four years later it was the most popular and bait poison used to control gastropod populations.

Metaldehyde is still commonly use throughout agriculture as a mode of controlling slug populations because of its comparable low cost per hectare. Metaldehyde accounts for nearly 85% of the slug pellet market (Rush 2010). The way in which metaldehyde works is it attacks and destroys the mucus glands which initially causes excess mucus production which leads to dehydration which renders the slug immobile and unable to rehydrate which leads to death.

Methiocarb like other carbamates derive from Physostigmine which occurs in Calabar beans. Its anticholinesterase activity was recognised in 1926 where tests were then carried out to assess insecticide properties.

Ferric phosphate is a chemical compound found throughout the natural environment (Talarek, 1997). Although it is unclear when ferric phosphate was first used as a Molluscicide literature suggests that it was after the first use of metaldehyde in the 1930s.

2.3 Detection of metaldehyde in raw water

In the autumn of 2007 more sensitive testing for metaldehyde in water began and was found to be at unacceptable levels in several water samples tested. Metaldehyde is a problem because it is very difficult to remove at any waterworks and could potentially poses health risks. Since metaldehyde was detected in raw surface water supplies increased awareness and tighter regulations regarding the use of metaldehyde have been brought into force. One metaldehyde pellet in 10,000 litres of water is enough to exceed recommended maximum levels (The Voluntary Initiative, 2008). 'Get Pelletwise' is a campaign setup to promote responsible use of metaldehyde by the Metaldehyde Stewardship Group (MSG) founded in 2009 in response to analysis showing traces of metaldehyde in water used for abstraction.

The way in which metaldehyde gets into raw water is through one of three pathways - Point source, Direct application and diffusion. Point sources can come in many forms from contaminated mud from vehicles to spillages caused when filling a spreader. Direct application is primarily caused by spreading pellets into surface water and ditches on field boundaries. Contamination by diffusion can be one of the more complicated pathways to control where contamination is through leaching through soil into field drains or run off after heavy rain (Hannah Goodwin,2010).

A maximum annual application of 700g/ha of metaldehyde and a maximum application of 210g metaldehyde a.s./ha between 1st August and 31st December has been imposed in an attempt to reduce run off into watercourses by the voluntary initiative Pelletwise. Along with the enforcement of a 6 metre buffer zone along the banks of any watercourse and delayed spreading when heavy rain is forecast.

Dr Andy Evans of SAC in 2009 at a NFU meeting warned that if the tight restrictions imposed on metaldehyde were not adhered to we would be in danger of losing metaldehyde. If this was to happen farmers would be force to look at other chemical control methods which would most likely involve the use of methiocarb or Ferric Phosphate and possibly biological control products such as Nemaslug. With metaldehyde costs averaging between £10 - £15/ha and methiocarb between £20 - £25/ha this could have financial implications on farmers.

2.4 Slugs

The Grey field slug is the most common slug species in arable crops. All slugs are hermaphrodite and so are both Male and female, one slug can lay up to 500 eggs in one growing season. The way in which slugs cause damage is through their feeding stripping of leaves, hollowing of seed or damage to tubers are common features of damage.

Slug activity is affected by three main factors Seedbed quality, temperature, and soil moisture. A open clod filled seedbed gives a desirable place for slugs to feed and breed this is because the clods not only give the slug somewhere to shelter but also allows them to easily move through the soil to access the seed and growing parts of a crop. Slugs are most active between 5°C and 17 °C although the gray field slug can remain active at temperatures close to freezing (James R. Baker).

2.5 This thesis

The aim of this thesis is to examine both the agronomic effects on agriculture if metaldehyde was removed from the UK market. Around 69% of Winter OSR & 30% of Winter Wheat is treated with slug pellets (Kynetic & CSL 2006/7) the loss of metaldehyde could have serious agronomic effects. Winter wheat could become more difficult to grow under slug attack.

The focus of this thesis will be on slugs in winter wheat. Field monitoring will be carried out in several locations though mainly on heavy clay and loam soils where seedbed structure can be poor due to sowing conditions.

3 Cultural control

3.1 seedbed

Seedbed formation can affect slug control, a seedbed that is open and has a cloddy structure is ideal for slug damage (David Glen. No date). This is because the slugs can move freely across the field and through the soil profile to gain access to the growing leaves of the crop, the seed and the root systems. A poor seedbed can be a result of both geological and environmental factors (Landis,2013). Figures 3.1.1 and 3.1.2 show the effect of rolling a seedbed to form a firm fine seedbed. In Figures 3.1.1 and 3.1.2 the headland and half of the main area of the field was rolled before heavy rain meant that the rest of the field could not be rolled. A clear line can be seen where the seedbed is much more open and slug damage is more prevalent. This nicely shows the importance of forming a fine firm seedbed.

Figure 3.1.1 Rolled Field 1. Figure by Author

Figure 3.1.2 Rolled Field 2. Figure by Author

Soil type can effect seedbed formation. Soils with high Clay content are more prone to slug problems than lighter sandy soils (Nigel MacDonald, 2009). This is not only due to the rougher cloddy seedbeds that can be formed in these soils but also the higher level of moisture retained within these seedbeds (David Glen, 2012). Slugs are reliant on moisture and mild temperatures for their life cycle (David Glen, 2012). In a growing season such as 2011 – 2012 and into the spring of 2013 where there were high levels of rain fall resulting in high moisture content in seedbeds along with mild ambient temperatures slug damage was very common in Autumn sown crops.

3.2 cropping

Both current and previous cropping can have an effect on slug populations. Autumn cereal cropping after beans, peas and Oilseed rape has a high risk of slug damage. This is because the slugs can multiply and feed under the dense canopy of the Oilseed rape, Peas or beans protected from bird and other predator attack. The canopy caused by oilseed rape, peas and beans also generates a micro climate which is sheltered from cold temperatures and has additional humidity which is beneficial to the slug life cycle.

Autumn sown crops are more prone to slug damage than spring sown crops. This is predominantly because of environmental conditions. As previously mentioned slugs require moisture and mild temperatures to live there life cycle. These conditions are more common in the autumn months.

3.3 Cultivations

Ploughing is generally more effective at controlling slug populations than Minimum tillage. This is not only due to the burring of trash which can supply the slugs with a food source but the mechanical disruption to the soil profile can cause damage to slugs. Slugs getting caught up in the mechanical inversion of the soil profile during ploughing can be buried deeper than they are able to migrate back to the surface. Slugs can also be destroyed by the sheering and grinding action of the soil during ploughing. As a rule of thumb for every soil cultivation soil living pest species can be reduced by half (Elcock, SAC 2003).

Stubble burning is a good method of controlling slug populations. Although stubble/straw burning is still legal in Scotland it is generally discouraged by the environmental regulators. The burning action may kill some slugs but the main control comes from the destruction of a food source in which the slugs can survive on. There have been campaigns to allow stubble/straw in England after the 1993 ban to help with the control of blackgrass on arable ground. To date this looks unlikely to be approved but if it was it would have the added benefit of controlling slug populations. Similar slug control to stubble/straw burning can be achieved by destroying the green bridge with desiccants. The disadvantage of this is the added cost even though Glyphosate based products can be relatively inexpensive.

3.4 Seed dressing

There are seed treatments that are known to prevent seed hollowing by slugs the most common being Redigo Deter. Redigo Deter is a seed dressing used in autumn cereals and comprises of an insecticide (Clothianidin) and fungicide (Prothioconazole). Around 40% of winter wheat is treated with Redigo Deter (Mike Abram. 2011). The Clothianidin in the Redigo Deter is a Neonicotinoid which affects the central nervous system of the target species. It is this that stops the slugs from feeding on the seed but no protection is given to the emerging shoots therefore additional control may be required at early growth stages. As of the November 30, 2013 seed treatments containing thiamethoxam, clothianidin and imidacloprid are no longer permitted in OSR and maze and winter cereals containing clothianidin based seed treatment such as Redigo Deter as of January 1, 2014 must be drilled before 31st of December due to a EU ban on the use of neonicotinoids.

4 Legislation to be considered

4.1 Operations & PPE

In order to legally apply all types of slug pellets the operator must hold a PA4S certificate. The objective of this certificate is to ensure operators are (NTPC, 2010):

- aware of the regulations which must be adhered to when applying pellets
- able to correctly calibrate the applicator
- able to carry out maintenance on the applicator
- able to clean personal protective equipment (PPE) and machinery that has been contaminated during slug pellet applications.

When applying pellets it is important that operators use the correct PPE. The minimum recommended PPE is as follows: overalls, Nitrile 0.5mm thick gloves, water repellent footwear and a face shield (Writtle College, 2013).

Bags of slug pellets should be stored undercover away from water courses and drains. Open bags should not be unattended at any time.

The most common method of applying Slug pellets is with a spinning disk broadcaster mounted either on the front of a tractor/sprayer or mounted on the back of a farm ATV. Both methods are equally acceptable and are generally determined on ground conditions, and tying in with other field operations.

4.2 Environmental Considerations

4.2.1 Methiocarb

There are many environmental considerations when using Methiocarb. Methiocarb does not just target slugs but all ground living animals including earth worms, beetles, Larvae etc. Therefore the effect on integrated pest management (IPM) strategies has to be considered. This can not only affect pest control from beneficial's in a crop but also soil structure. Earthworms play an essential part in maintaining soil structure by breaking down organic matter and aerating the soil profile during their burrowing process.

A 6m buffer zone is required along all field boundaries and a maximum individual dose of 3.75Kg/ha in Cereals. A Maximum of 10kg/ha of product per year in cereals which must be applied before GS31.

On the 25th March 2014 a withdrawal notice for Methiocarb was issued based on its effect on non target organisms especially birds. Authorisation ends in 18th September 2014 for the sale and distribution by any persons and 19th September 2015 for the disposal, storage and use of existing stocks by any persons (Bayer. No Date).

4.2.2 Metaldehyde

Metaldehide is more selective than Methiocarb and does not affect beneficial insects (David Glen. No date). The main problem associated with Metaldehyde is leaching into watercourses. The Metaldehyde Stewardship Group was setup in 2009 in response to increasing levels of Metaldehyde found in catchments used for water abstraction (Get Pellet wise,2013). In 2012 increased restrictions on the use of Metaldehyde were introduced between 1st August and the 31 December a maximum application of active must not exceed 210g/ha and a maximum of 700g/ha in a calendar year (get Pellet wise, 2013). Metaldehyde Must not be applied within 6m of watercourses and on ground where drains are flowing with water (Get Pellet Wise, 2013).

4.2.3 Ferric Phosphate

Unlike Methiocarb and Metaldehide Ferric Phosphate has no restrictions with regards to buffer zones from water courses. This is because it is a naturally occurring substance in soil. Ferric Phosphate does have restrictions on application rates a maximum application of 7kg/ha can be applied at once and a maximum dose of 28kg/ha in one cropping season (Derrex, 2011).

5 Method

5.1 Pellet Efficacy

The pellet efficacy will be assessed by preparing six trays filled with 10 cm of field top soil which will be collected from the same location to ensure that soil type (sandy clay loam) and previous cropping (spring Barley)remains constant across all three trays. Wheat shall be hand sown to a depth of 4cm into the trays and left for two weeks to germinate Figure5.1.1

Figure 5.1.1 Prepared trays. Figure by Author

Once the trays have been constructed slugs were collected from neighbouring arable fields using slug traps constructed from a tile and some layers mash. Traps were left over night and inspected in the morning where the slugs were collected and stored in a jar Figure 5.1.2 until sufficient slugs had been collected. All slugs used in this experiment were gray field slugs.

Figure 5.1.2 slug collection jar. Figure by Author

Twelve slugs shall be counted out and placed into each of the six trays. Using the max application rate which are as follows Draza Forte (4% methiocarb)- 3.75kg/ha (35 pellets/ m^2)

Derrex (29700g/kg ferric phosphate) - 7kg/ha (66 pellets/ m^2)

Carakol 3 (3% metaldehyde) - 11.5kg/ha (108 pellets/ m^2)

The following calculation has to be done for each slug pellet type to calculate the correct application rate per tray:

Each tray is = 0.76m x 0.47m = 0.36 m^2

Draza Forte = 35 x 0.36 = 12.6 pellets/tray

Derrex = 66 x 0.36 = 23.8 pellets/tray

Carakol = 108 x 0.36 = 38.9 pellets/tray

Three trays shall then have the maximum application of slug pellets applied to them the remaining three trays will have a half dose applied to them. Figure 5.1.4. The slug pellets shall be applied manually wearing the appropriate PPE (protective overalls and gloves)

Figure 5.1.4 slug with pellet. Figure by Author

For seven days the living slug population of each of the trays will be noted along with the atmospheric temperature. Results shall be plotted on the following table 5.1.1

Maximum application														
Pellet type	Monday slug population	Monday average Temp	Tuesday slug population	Tuesday average Temp	Wednesday slug population	Wednesday Average Temp	Thursday slug population	Thursday Average Temp	Friday slug population	Friday Average Temp	Saturday slug population	Saturday Average Temp	Sunday slug population	Sunday Average Temp
Draza														
Derrex														
Carakol														
Damage notes														

Table 5.1.1 slug population sheet. Table by Author

5.2 Field Survey

Three fields were selected on a SW facing Perthshire farm each field was a sandy clay loam sown in winter wheat using an Amazone 303 conventional drill with power harrow followed by an autumn slug control program using only one of the three actives per field. All fields were previously in oilseed rape and had a slug population above threshold at sowing. The last application was applied on the 5th November and the fields were inspected on 12th November. Black Drums field was treated with metaldehyde, Standard A field was treated with methiocarb and Lornie field was treated with Ferric Phosphate (figure 5.2.1)

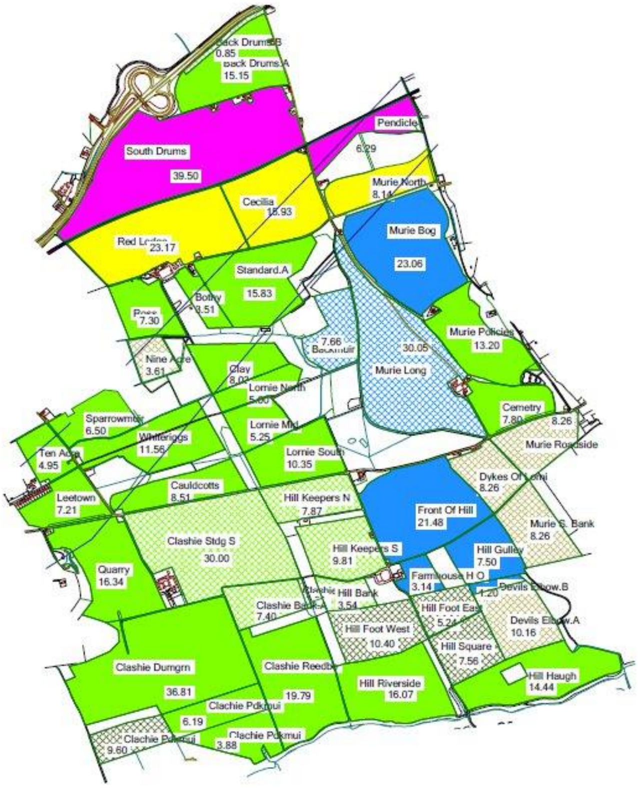

Figure 5.2.1 farm map. Figure by Author

As all fields were under 20ha only nine traps (thirteen should be used in fields larger than 20ha) were set using chicken layer's mash in a "W" pattern across the fields as shown in figure 2.2.2. The traps were inspected the following day when leaf damage was assessed across the field.

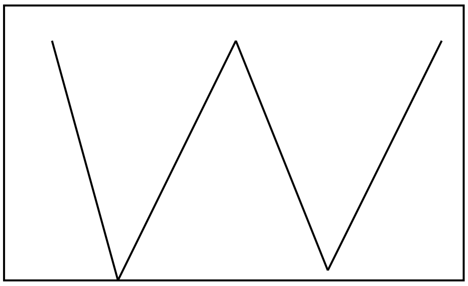

Figure 5.2.2 "W" walking pattern. Figure by Author

Leaf damage was assessed using a 25cm quadrant following the same “W” pattern across the field (figure 5.2.3)

Figure 5.2.3 Quadrant. Figure by Author

6 Results

6.1 Pellet Efficacy

The amount of damaged to true leaves over 7 days was monitored and the following results were obtained.

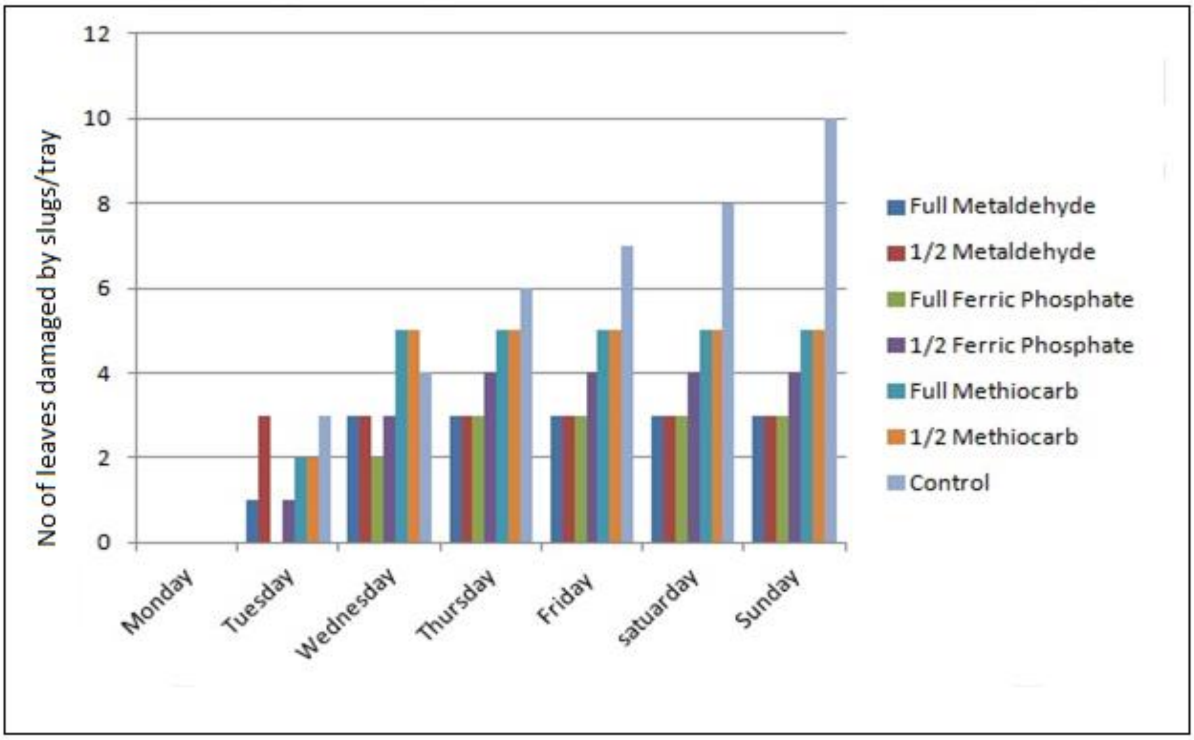

Figure 6.1.1. Number of leaves damaged by slugs. Figure by Author

As can be seen from figure 6.1.1 all actives whether they were at the max application or at a half rate had an effect on slug damage. Metaldehyde and Methiocarb showed no difference in effectiveness when comparing the difference between half and full rate. Ferric Phosphate on the other hand appeared to give better slug control at the maximum application than it did at a half rate. Both Metaldehyde and Methiocarb achieved full control of the slug damage by day three where no further leaf damage occurred it was only ferric phosphate that required an extra 24 hours before leaf damage stopped.

The trays with Metaldehyde displayed clear signs of where the slugs had been affected by the pellets (figure 6.1.2). The way in which Metaldehyde works is by causing damage to the mucus cells of the slug which causes it to over produce mucus which eventually leads to the slug becoming dehydrated before finally dying. This could be seen in several locations around the trays treated with Metaldehyde.

Figure 6.1.2 Slug pellet. Figure by Author

The reason that the Ferric phosphate slug pellets took slightly longer to control the slug damage could be down to the way in which Ferric Phosphate affects slugs. Ferric Phosphate causes pathological changes to a slug's digestive system to the point it stops feeding. It can take between three to six days for a slug to stop feeding and die (Garden Organic, 2013). Slugs which have been affected by ferric phosphate generally leave no visible signs on the soil surface like Metaldehyde instead they prefer to move under the soil surface.

The results acquired from this experiment would suggest that Metaldehyde was faster acting than Methiocarb and Ferric Phosphate was the slowest acting. All three active ingredients gave good control of slug damage when compared to the control tray.

6.2 Field survey

The field survey gave the following results. Figure 6.2.1 shows the average damaged leaves for each active over $25cm^2$. The results gained from this experiment show that in a field application Methiocarb has the greatest control of a slug population followed by Metaldehyde and then Ferric Phosphate.

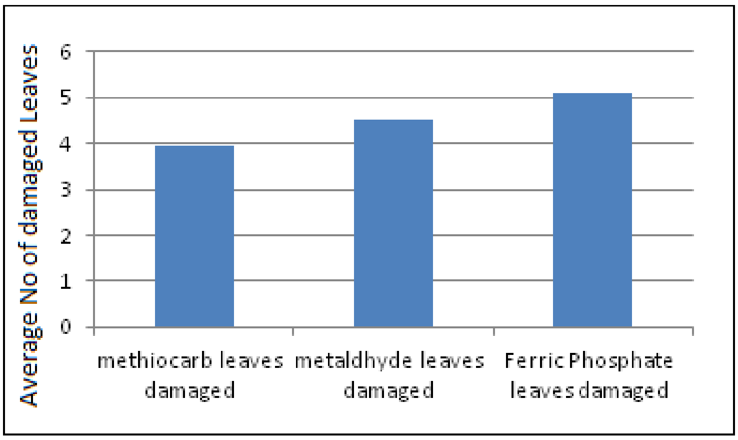

Figure 6.2.1 Average number of damaged leaves per active ingredient. Figure by Author

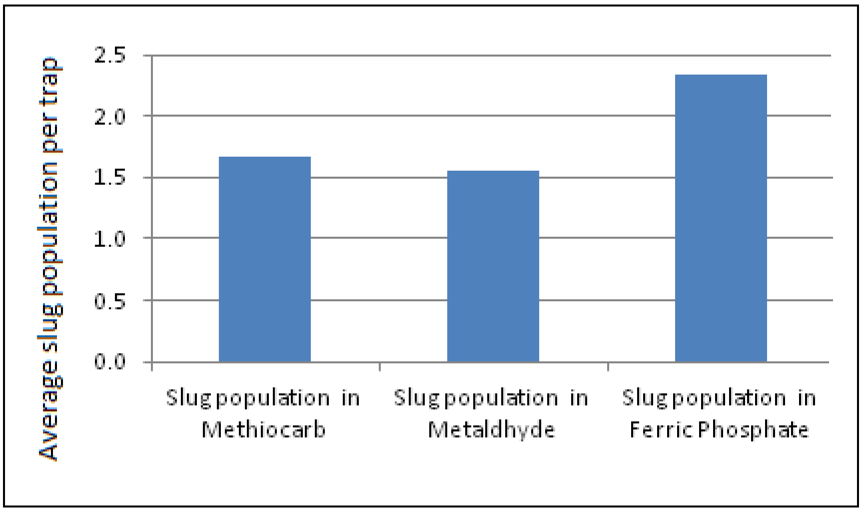

Figure 6.2.2 Average slug population per trap. Figure by Author

Interestingly the average slug population in the traps (figure 6.2.2) seems to suggest that the slugs which were in contact with Ferric Phosphate were returning to the trapping points. This can be interpreted in several ways:

1. The slugs were seeking shelter under the trap as they would under clods etc
2. The slugs were not consuming a fatal dose of ferric phosphate due to the presences of other food sources
3. The ferric phosphate was taking longer than expected to affect slug feeding

Having the lowest level of slugs present in the field treated with Metaldehyde would be expected as metaldehyde is fast acting on slugs. A slug that is affected by Metaldehyde can no longer effectively move over or through soil and so it would no longer be able to access the trapping points.

Again the effect of Methiocarb on slugs very noticeable although there is slightly higher population of slugs in the traps located in the Methiocarb treated field this could be answered by the way in which Methiocarb affects slugs. Slugs that have been in contact with Methiocarb tend to move below the soil surface or under stones before they die. This could cause this result to be described as misleading and would require additional assessments to be carried out in order to confirm this. Slugs were randomly selected from the traps across the methiocarb treated field and were tested for signs of life. All of the slugs that were tested showed no response reflexes and so can be considered dead.

7 Conclusion

7.1 Active Efficacy

There are some contradictions in data generated by the two experiments where experiment one looking at dose rates suggested that Metaldehyde had a higher control rate than Methiocarb where in experiment two methiocarb had the highest control of the three actives. Additional research into this showed that trials carried out by Scottish agronomy (Farmers Guardian,2010) confirm the results found in experiment two. This raises the question why are there conflicting results in experiment one? This could be put down to the amount of pellets per m^2 the maximum application rate of Metaldehyde is over three times that of methiocarb therefore each slug has less distance to travel before becoming in contact with a pellet.

From the data generated in experiment one we can assume there is no significant difference between full and half rate applications when using Methiocarb and metaldehyde. This could be due to the high toxicity to both actives. There did appear to be a difference between full and half rate ferric phosphate this could be due to its lower toxicity and therefore it took longer for a slug to consume a fatal dose.

Form this we can say that in order to keep within the maximum application rates set for Metaldehyde and Methiocarb half applications can safely be used without having any negative effect on slug control. Ferric Phosphate on the other hand would appear to require higher application rates in order to achieve desirable control levels.

Experiment two showed the control of slugs in three fields using the three main actives following a typical slug pellet application program. This experiment clearly showed that Methiocarb has the highest rate of control followed by metaldehyde and finally Ferric phosphate. These results are supported by results gained by Scottish agronomy (Farmers Guardian,2010). This experiment also looked at the slug population found in traps after pellet applications. The results from this part of experiment two shows the mode of action that each active has on a slug. The field that was treated with metaldehyde had the least amount of slugs present in the traps this is because slugs which have been in contact with metaldehyde quickly lose control over their ability to control their mucus production. This results in them producing excessive amounts of mucus which stops them from being able to effectively move across the soil and eventually results in the slug dehydrating which leads to death.

Initially the data gathered from the traps in the field treated with methiocarb was confusing and unexpected. It is generally agreed that slugs that have been in contact with methiocarb move under the soil surface before they die, but in this experiment they were returning to the traps where they were dying. After reviewing the field ground conditions looking for answers it was apparent that this could be accounted for by the formation of a thin crust that had formed due to the breaking down of the soil particles by persistent rain. This had meant that the slugs could no longer move under the soil surface and were seeking shelter under stones and the traps instead.

The field which was treated with Ferric Phosphate had the highest amount of slugs in the traps this is because Ferric Phosphate is not as fast acting as Methiocarb and metaldehyde and slugs are slow to reduce their feeding as their digestive system is disrupted. Slugs found in the traps had a blue colouring to their stomach area which is indicative of ferric phosphate poisoning.

7.2 Cultural control

Cultural control is and always will be the first mode of action when controlling slug populations. The importance of establishing a firm and fine seedbed has been confirmed as being an important factor when controlling slugs. Although this is not always possible due to environmental or geological conditions.

When following crops known to generate high slug populations extra seedbed preparations can be carried out to help reduce this pressure. By removing food sources from the stubble can help to reduce slug populations this can be achieved by desiccation of the green bridge.

7.3 Legislation

Although the current legislation has helped to reduce the levels of Metaldehyde escaping into water courses the effects of the exceptionally wet conditions which occurred in the season of 2011 – 2012 resulted in unprecedented levels of metaldehyde being found in water catchment areas.

An option that might be possible on a small scale is to apply ferric phosphate pellets in an increased 8m buffer zone around the whole field and only use metaldehyde in the main cropping area. The practicalities of this on large scale farms where large areas of land have to be managed with limited time and labour resources are low.

Since this project was started in autumn 2012 Methiocarb has had a withdrawal notice issued this prevents the sale of Methiocarb from the 18th September 2014 and all stocks must be disposed of or used by 19th September 2015. This has resulted in only metaldehyde and ferric phosphate being available for future crops. This puts significant pressure on retaining these last remaining Molluscicides.

Further reducing the maximum metaldehyde rates during autumn and in April when statistically the highest amount of rain fall occurs could be an option. According to Rodger Highfield of the telegraph scientific models suggest that extreme rain storms could rise by 10% by 2050. As it is during extreme rain storms that the largest amount of runoff occurs on fields this will result in significant problems for the future. It is not possible to definitively say how we will be controlling slugs in the future but if these projections are correct a more stable or less toxic chemistry will have to be adopted with extra attention to detail being carried out during seedbed formation.

7.4 Limitations

The outcomes of the experiments carried out as part of this project were affected by external factors. These factors include natural predators along with weather conditions, ambient and soil temperatures. This will have affected the results collected in this project but without a comparison being done in scientifically controlled environment this cannot be quantified.

Due to the size of the data sets collated it is difficult to assess the statistical significance of this project. This could be improved by repeated experiments over several growing seasons or increased sample size.

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