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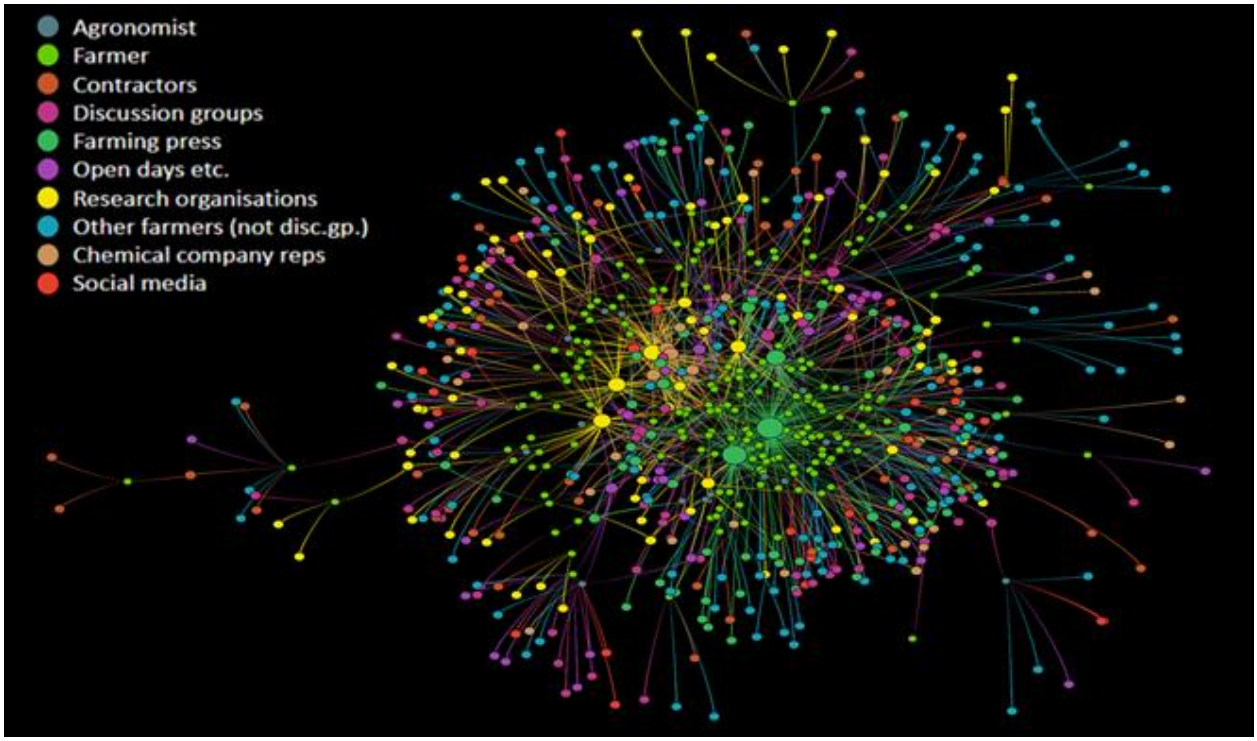
Perceptions of pest risk and differences in IPM uptake by arable farmers and agronomists in Scotland

Project Final Report



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Content

1 Summary

- Better informed arable farmers and agronomists can make better IPM decisions. By identifying IPM information networks it may be possible to improve the flow of information to farmers by targeting their preferred information sources.

- In 2021 a telephone survey of 267 arable and mixed arable/livestock farmers and 26 agronomists collected information on currently perceived invertebrate pest, disease and weed threats in Scotland, the level of IPM uptake, and the information sources consulted.

- Many factors were found to influence IPM uptake including farm type (arable specialists scored higher than mixed farmers), location (East of Scotland performed best), using an agronomist (increased uptake), farmer age (younger farmers had higher IPM scores), farmer education (having a formal education increased score). Members of Linking Environment And Farming (LEAF), a scheme that farmers pay into which promotes IPM had higher IPM scores.

- Arable farmer and agronomist perceptions on the greatest pest threats aligned on slugs, leatherjackets and blackgrass. Agronomists perceived diseases, such as Septoria and Ramularia, to be a greater threat to production than farmers did. This could be because farmers often outsource disease management responsibilities to their agronomist, who are more skilled in disease diagnostics and have current knowledge of suitable control measures (including changes in pesticide efficacy and varietal resistance status) so agronomists are more aware of the threat posed by disease.

- Agronomists and arable farmers perceived varietal resistance to be the most effective measure for controlling diseases, whereas all measures were perceived to be equally effective at controlling invertebrate pests.

- Agronomists and arable farmers acquire IPM knowledge from a range of information sources the most popular being their peers, research organisations, farming press, levy boards and professional memberships.

- Agronomists were more likely to use social media than arable farmers, whereas farmers were more likely to gain IPM information from the farming press.

- Information networks have identified the key role of peers, a small number of the farming press and several research organisations in spreading IPM information.

- The biggest barrier to further IPM uptake was 'time and effort required to increase knowledge of IPM' for arable farmers, and for agronomists it was 'market constraints', which could potentially be overcome by working with the retailers and consumers to collectively relax certain constraints related to superficial quality specifications. This would make 'insurance sprays' unprofitable and would also reduce food waste.

- Knowledge of the information networks can improve delivery of IPM messages by channelling the information through arable farmers preferred information sources.

- Improved knowledge of IPM practices will allow arable farmers to effectively engage in IPM discussions with their agronomist, allowing for co-development of the IPM strategy.

2 Recommendations

- Develop a Knowledge Transfer and Exchange (KTE) strategy and plan that presents IPM in simple actions and seeks to reduce the perception that it is complicated and costly.
- Agronomist advice is one of the major drivers of IPM score and understanding their characteristics and motivations is a key gap to explore.
- Improved knowledge of IPM practices will allow farmers to effectively engage in IPM discussions with their agronomist, allowing for co-development of the IPM strategy.
- Farmer and agronomist perceptions on barriers to adoption varied significantly. This implies very different KTE needs. Agronomists require technical information on pesticide efficacy and disease management. Arable farmers require information on cultural solutions to managing weeds and invertebrate pests.
- IPM advice must be tailored to the farming system as the potential and need for IPM differs according to the crop and its intended end-market. In Scotland, mixed farmers commonly grow grass and feed spring barley. There is often greater potential to increase IPM uptake in these feed crops that are less affected by market constraints relating to quality and for which fewer barriers to pesticide reduction exist.
- Most arable farmers exchange IPM information with peers. Local discussion groups could be used to support mixed farmers to uptake more IPM practices especially if an adviser knowledgeable in IPM facilitates the discussions around what IPM practices are particularly beneficial and feasible within the constraints and capabilities of mixed farms.
- Future IPM research and developments should consider the differences in perceptions and priorities of farmers and agronomists. This is especially important when targeting either mixed farmers or specialist arable farmers who may target different quality specification related to the markets (e.g. animal feed, human consumption).
- There are many factors that influence pesticide usage e.g. local environmental conditions, specific crops grown, target market. To further understand the relationship between IPM uptake and pesticide usage a detailed survey that considers all aspects of the farm and farming business is required.
- KTE should utilize the most effective outlets - farming press, levy boards, research organizations and professional memberships for the key decision makers involved, for example focusing more on the farming press for Scottish arable farmers and social media for their agronomists.

3 Introduction

Integrated Pest Management (IPM) is a holistic approach to managing pests that combines an optimal mix of tools and techniques to maximize productivity and profitability whilst minimizing the negative impacts of crop production on the environment, namely by reducing the need for agrochemical use. Empirical evidence suggests that careful application of IPM practices can be a viable way to prevent the overuse and unnecessary application of pesticides without incurring significant yield losses (Jacquet F. et al. 2012: Lechenet M. et al. 2014; Lechenet M et al. 2017) though this is debated (Di Tullio E, et al. 2012; Hossard L. et al. 2014).

IPM is often defined as a knowledge-intensive process in which farmers select options from a range of pest management measures which meet the multiple objectives of maintaining crop productivity and profitability and reducing environmental impacts (Byerlee D. 1996). This suggests that farmers will need to develop a high level of understanding of IPM, or have access to such knowledge, before high levels of IPM adoption could be achieved. Several European studies have found that farmer information-seeking behaviour and, in particular, engagement with IPM experts, increased IPM adoption (Jorgensen L.N. et al. 2008; Creissen et al. 2021).

Better-informed farmers and agronomists can make better IPM decisions. It may be possible to improve the flow of IPM related information by identifying their preferred information sources and channelling key messages through those sources. Knowledge transfer and exchange (KTE) activities can influence farmers and agronomists' perceptions on the most significant pest threats, the effectiveness of control measures, and the risks associated with the various different management approaches. This may offer potential insight into ways in which KTE can be optimized to overcome barriers related to perceptions, advice and guidance, to further adoption of IPM practice.

This project conducted telephone interviews of agronomists and arable/mixed arable and livestock farmers to:

1) Identify the key factors that influence IPM adoption and the barriers to further adoption.
2) Collect information on currently perceived invertebrate pest, weed and disease threats to Scottish crops and the effectiveness of associated control measures.
3) Identify the key IPM information and data sources.
4) Identify any intervention tools or methods that might be needed to manipulate or change how information flows.

4 Methodology

SRUC designed a questionnaire directed at arable farmers and agronomists across Scotland in which information was gathered on; 1) invertebrate pests, weeds and diseases currently perceived to be the greatest threat to arable production, 2) sociodemographic data related to the farm and the farmer, 3) level of IPM adoption as assessed by IPM score (Creissen et al. 2019) and 4) the recipients preferred and most heavily utilised IPM information sources. The interview template/questionnaire was refined after several rounds of piloting with the contractor responsible for data collection (ipsos MORI) so that the phone interviews could be completed within 20 minutes (see Appendix 1 for the interview template).

The contractor gathered a representative sample of arable farmers based on the Scottish Agricultural Census. Agronomists contact details were gathered through online Google searches and through targeted emails, sent to senior agronomists managing agronomists across Scotland to achieve an approximately geographically representative sample. In total 267 arable farmers and 26 agronomists were interviewed.

Differences in IPM uptake and perceived threats were examined and related to information sources (internet sources farming press, agronomist advice, research organisations etc.). The naturally occurring social network was captured (sources of information and interactions between sources are identified) which is useful in identifying first-degree information flows – something that is particularly important in identifying sources of misinformation in social networks.

Data used to create farmer information networks came from a random name generating question asked of all survey respondents. The process occurred in two steps: first, respondents were asked to identify which information category they received information from related to IPM; second, respondents were asked to name the specific person from each category. This two-step approach allows for a high level of detail to be mapped in the way farmers received information related to IPM.

5 Results and Discussion

Many factors were found to influence IPM uptake (as assessed by IPM score, see Creissen et al. 2019). Specialist crop producers (who do not cite grass as one of their most economically important crops) achieved the highest IPM scores ($p<0.001$, Appendix 2). Such farmers are often located in the East of Scotland ($p<0.1$ to $p<0.001$ depending on region, Appendix 2). Using an agronomist increased IPM score ($p<0.001$, Appendix 2), but there were no statistically significant differences between agronomist type (agronomists were classified as 'independent', if pay is unrelated to sales, or 'dependent' if pay is related to sales whether by salary or commission). Younger farmers had higher IPM scores ($p<0.001$, Appendix 2), as did those who had some formal farming related qualification ($p<0.001$, Appendix 2).

5.1 Demographics

IPM can be considered a knowledge intensive process with many interacting components and trade-offs to consider. Past experience, level of education and distance to retirement are just some of the factors that can potentially influence willingness and ability to undertake high levels of IPM practice.

The mean and median age of arable farmers surveyed is 59, with half of respondents reporting ages lower than 59 and half above 59 (Table 1). The majority (75%) of arable farmers in the sample range in age between 25 and 69 (Table 1). The sample roughly matches the Scottish Agriculture Census. Level of IPM uptake (assessed by IPM Score, see Creissen et al. 2019) was lower for those farmers over the age of 65 (Figure 1).

5.1.1 Farmer Age

Table 1a 1- Age summary statistics

Minimum	Q1	Median	Mean	Q3	Maximum
25	50	59	59	69	87

Table 1b 2- Respondent age categories

[1]Age quota	n	Percent
Under 41	24	8.3%
41-54	85	29.3%
55-64	82	28.3%
65 and over	99	34.1%
[1]Age categories correspond proportionally to the Scottish Agriculture Census.		

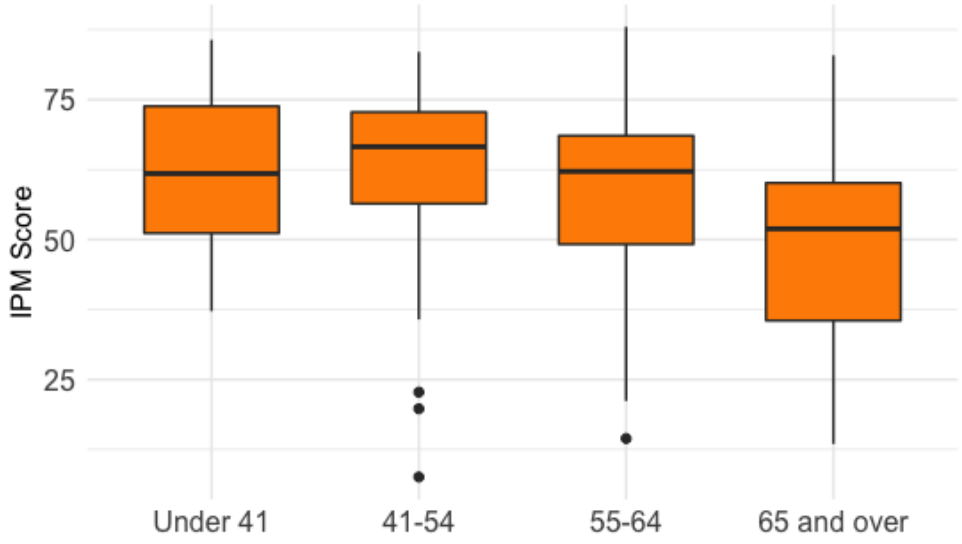

Figure 1 - IPM score (0-100) and Age bracket in years.

Error bars are 95% confidence intervals. The ANOVA that the main effect of Age is statistically significant ($p<0.001$, Appendix 2).

5.1.2 Education & Qualifications

Educated arable farmers are more likely to be able to acquire and implement the required knowledge through a combination of previous learning and an increased ability to make better decisions on farm. This statement holds true in this study. Half of the respondents who answered the question had no formal education beyond secondary school (Table 2) and had lower IPM scores ($p<0.001$, Appendix 2; Figure 2). Only one of three models showed there is an advantage of having a Bachelor's degree over a Diploma (Model 2, Appendix 2) meaning that the benefit of formal education on IPM is attained at the Diploma level (Figure 2). This may be because the practical nature of these qualifications is well suited to encourage IPM practice.

Table 23 - Respondent level of education

Level of education	Total
None	125
National Diploma	66
Bachelor's Degree	35
Higher degree	12

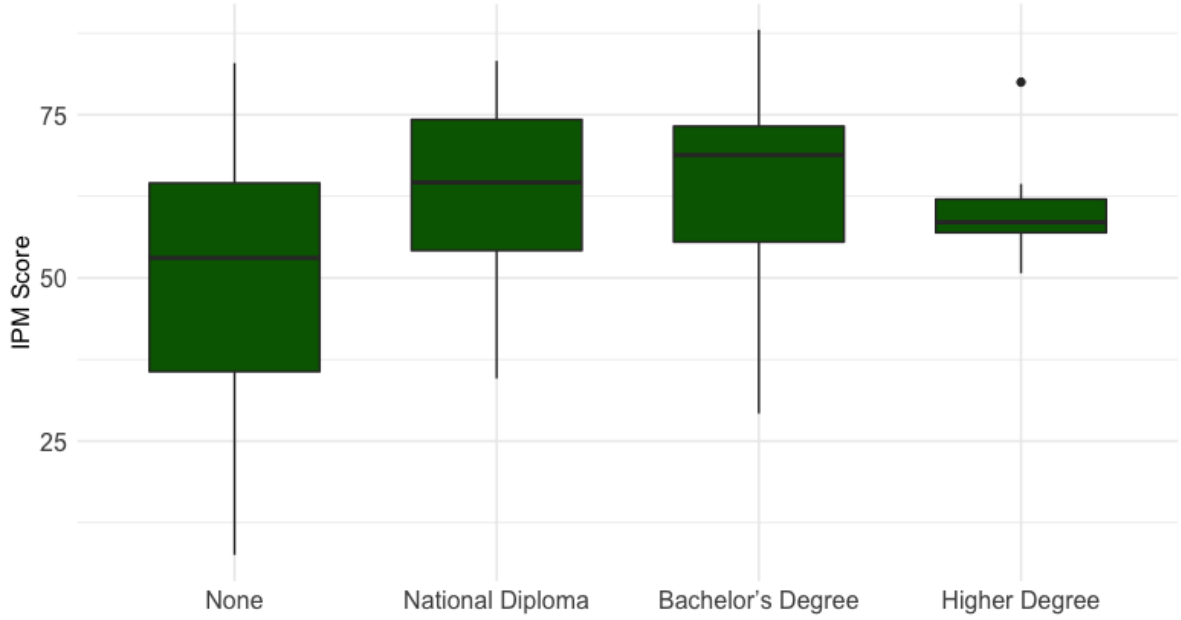

Figure 2 - Farmer level of education and IPM score

5.1.3 Geographic location

Differences in IPM score were seen between different local authorities (Table 3). Being a representative sample of arable and arable/livestock mixed farmers in Scotland there were many more responses from the East of Scotland e.g. Aberdeenshire, Angus, Fife, Moray, Peth and Kinross etc. than in the West e.g. Argyll and Bute, Ayrshire, Lanarkshire etc. (Table 3). IPM scores were also higher in the East of Scotland where a higher proportion of crop producing specialist are located (Table 3, Figure 3).

Table 34 - Local Authority Area and IPM Scores

Local Authority	Average IPM Score	Std. Dev	[1]Total Responses
Aberdeen City	46.4	20.9	7
Aberdeenshire	56.9	14.7	97
Angus	65.8	11.7	41
Argyll and Bute	45.9	15.8	5
City of Edinburgh	51.8	21.6	4
Clackmannanshire	65.5	14.2	5
Dumfries and Galloway	47.2	16.2	27
Dundee City	71.6	8.9	5
East Ayrshire	43.5	15.0	14
East Dunbartonshire	55.9	13.7	2
East Lothian	61.4	13.3	16
East Renfrewshire	40.4	21.9	5
Falkirk	52.8	23.7	3
Fife	61.8	17.6	31
Glasgow City	33.4	12.5	3
Highland	58.1	13.9	18
Inverclyde	16.8		1
Midlothian	58.1	13.0	8
Moray	57.1	14.0	35
North Ayrshire	42.1	17.2	5
North Lanarkshire	49.6	12.5	7
Orkney Islands	49.3	9.7	5
Perth and Kinross	62.8	13.3	32
Renfrewshire	22.4	9.7	3
Scottish Borders	63.3	13.0	35
Shetland Islands	37.2		1

South Ayrshire	49.4	16.4	12
South Lanarkshire	48.7	12.4	12
Stirling	54.2	13.9	9
West Dunbartonshire	65.6		1
West Lothian	54.1	15.0	9
[1]Farms cross local authority borders and may be counted in more than one local authority area.			

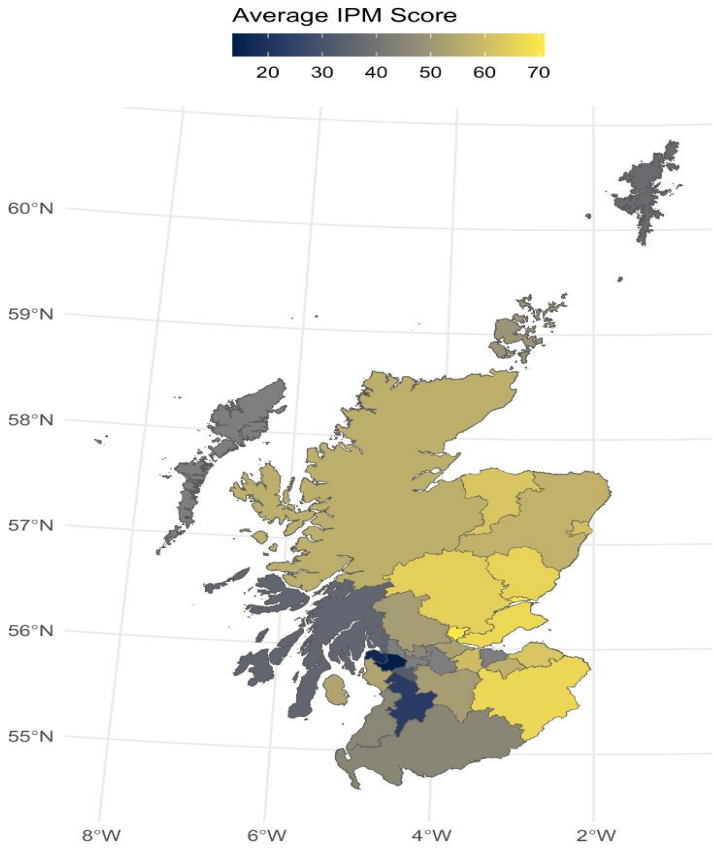

Figure 3 – Arable farmers IPM scores by geographic location

5.2 Farm characteristics

5.2.1 Economically important crops

The data collected on the farmer's three most economically important crops showed a representative sample with spring barley and winter wheat being the most selected crops (Table 4).

Table 4 5- Top 10 Most Economically important Crops

Rank	Category	Sub-category	Total responses	Percent
1st	Barley	Spring	195	30.6%
2nd	Wheat	Winter	111	17.4%
3rd	Grass	Sown in the last five years	70	11.0%
4th	Oilseed	Winter	61	9.6%
5th	Grass	Over five years old	46	7.2%
6th	Barley	Winter	37	5.8%
7th	Grass	Permanent pasture	35	5.5%
8th	Potato	Seed	31	4.9%
9th	Potato	Maincrop	27	4.2%
10th	Oats	Spring	25	3.9%
NOTE: Respondents were asked to name their top three most economically important crops.				

Farmers growing crops such as oilseed rape and winter wheat often had higher overall IPM scores (Figure 4). These crops have significant pest threats that have the potential to not only reduce yield but destroy entire crops if left unchecked. The wheat diseases Septoria and yellow rust often drive crop variety and fungicide decisions in Scotland. In oilseed rape, cabbage stem flea beetle poses a significant threat due to a lack of availability of effective pesticides to control it since neonicotinoids were prohibited. Currently available non-chemical control options alone do not offer adequate control of either these biotic threats.

Mixed farmers i.e. those growing grass, had lower IPM scores indicating that more engagement is needed with this sector to promote IPM activities. Mixed farmers predominately grow spring barley and grass (Table 5). As only 6% of mixed farmers who grow spring barley cited end-market as in important factor when selecting a variety, it is highly likely they are growing crops for animal feed and bedding. The potential for IPM in feed crops with fewer market barriers, related to quality requirements, is high. More investment in IPM research and KTE targeted towards mixed farmers growing feed spring barley could lead to increased IPM uptake and reduced use of pesticides in Scottish feed crops.

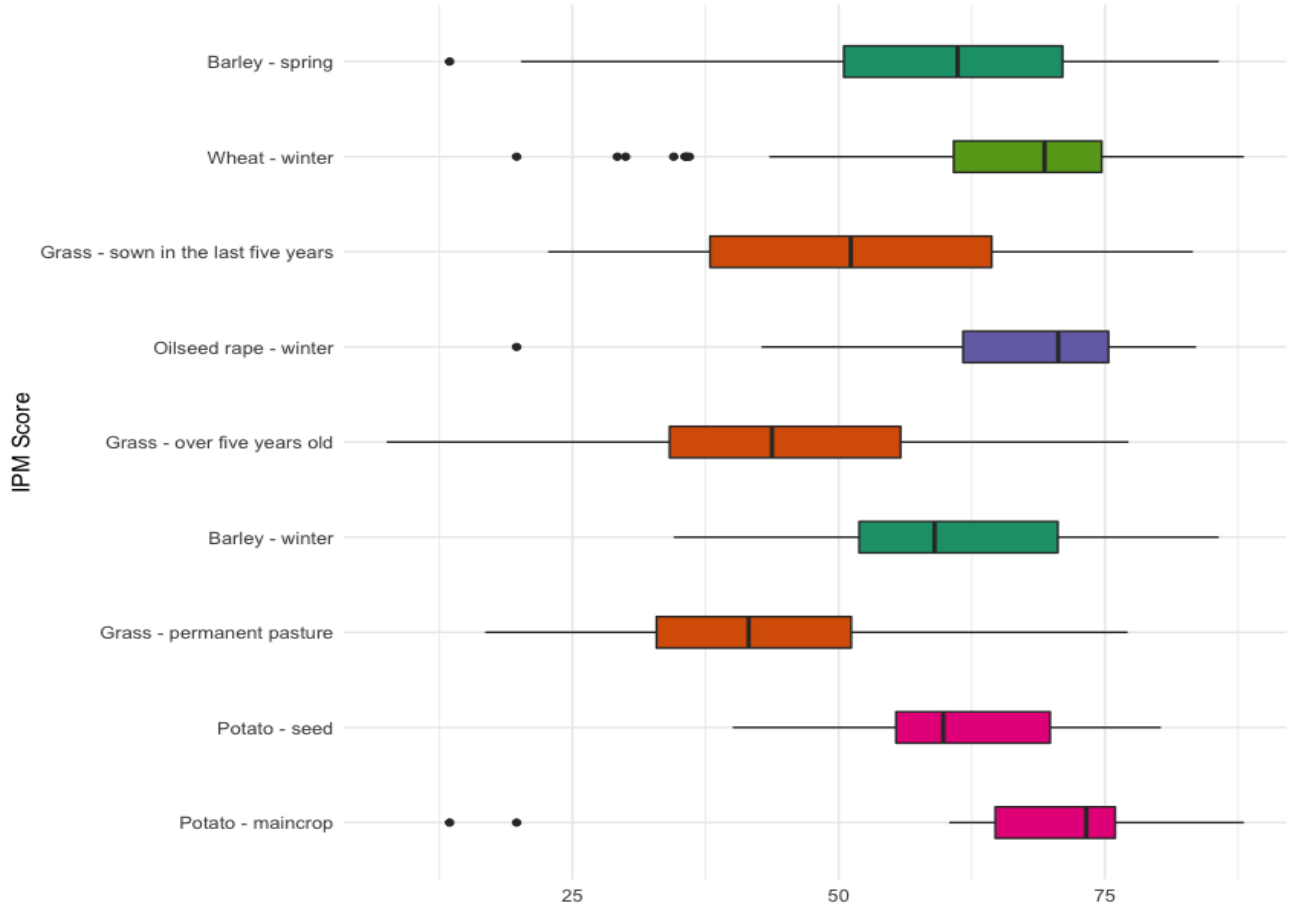

Figure 4 - IPM score in relation to most economically important crops grown. The main effect of crop is statistically significant and large ($p<0.001$).

Table 5 - Crops grown by famers who cite grass as one of their three most economically important crops.

Economically important crop	n	percent
Barley - spring	47	27.3%
Grass - sown in the last five years	45	26.2%
Grass - over five years old	22	12.8%
Grass - permanent pasture	15	8.7%
Wheat - winter	8	4.7%
Barley - winter	6	3.5%
Turnip	6	3.5%
Grass - rough grazing	5	2.9%
Potato - seed	4	2.3%
Oats - spring	3	1.7%
Oilseed rape - winter	3	1.7%

5.2.2 Farmland ownership

Most arable farmers owned all their farmland or rented and owned it (Table 6). Farmers who do not rent any land had slightly lower IPM scores (Figure 5). Taking on new land for farming often requires more investment, in terms of IPM knowledge and actions, than continuing to farm land with a known history (related to invertebrate pests, weeds and diseases).

Table 66 – Land ownership

Land category	Total responses	Percent
Owner only	139	47.8%
Own & rent	120	41.2%
Renter only	32	11.0%

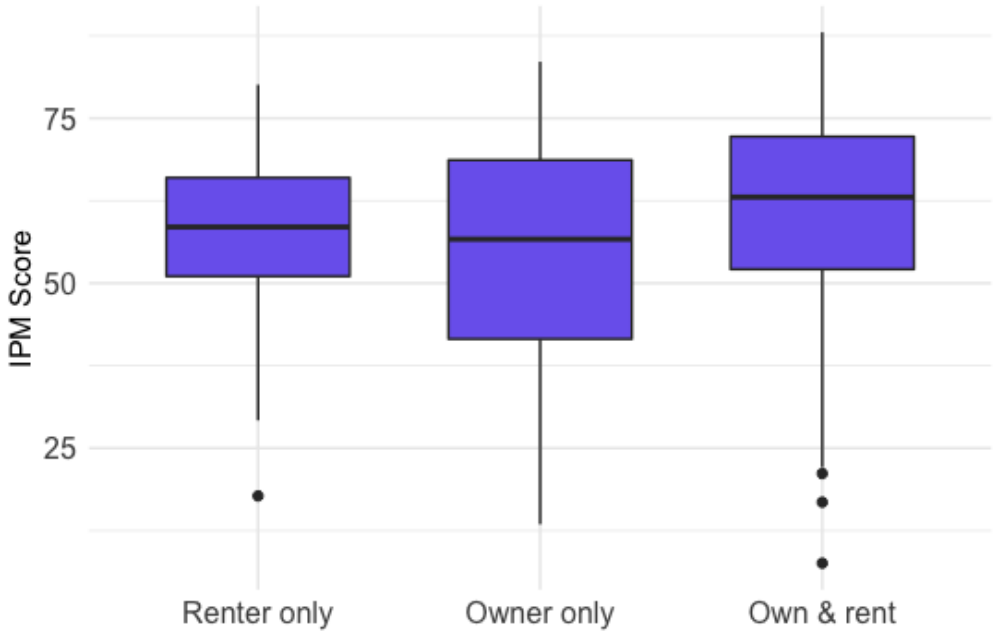

Figure 5 - IPM score in relation to land owned/rented. The ANOVA suggests that the main effect of land ownership category is small and statistically significant (p<0.001).

5.2.3 Farm specialty

Farmers with most of their land in arable production had higher IPM scores (Figure 6), a finding that is supported by other studies which showed a correlation between arable area and IPM adoption (Sawinska et al. 2020; Creissen et al. 2021). There are many potential reasons for the observed correlations between arable area and IPM score. Larger, arable specialist businesses have more capacity to buy in machinery and labour that may be required to implement IPM to a high level. Such farms typically have more opportunity to grow a greater number of crops and diversify the rotation as they often have more fields, sometimes with different soil types to allow for the cultivation of different crops in space and time. They are also more likely to employ a farm manager and have an in-house agronomist with IPM implementation being one of their main responsibilities. These farmers are also more likely to seek out and buy in extra advice from different agronomists etc. (Creissen et al. 2021).

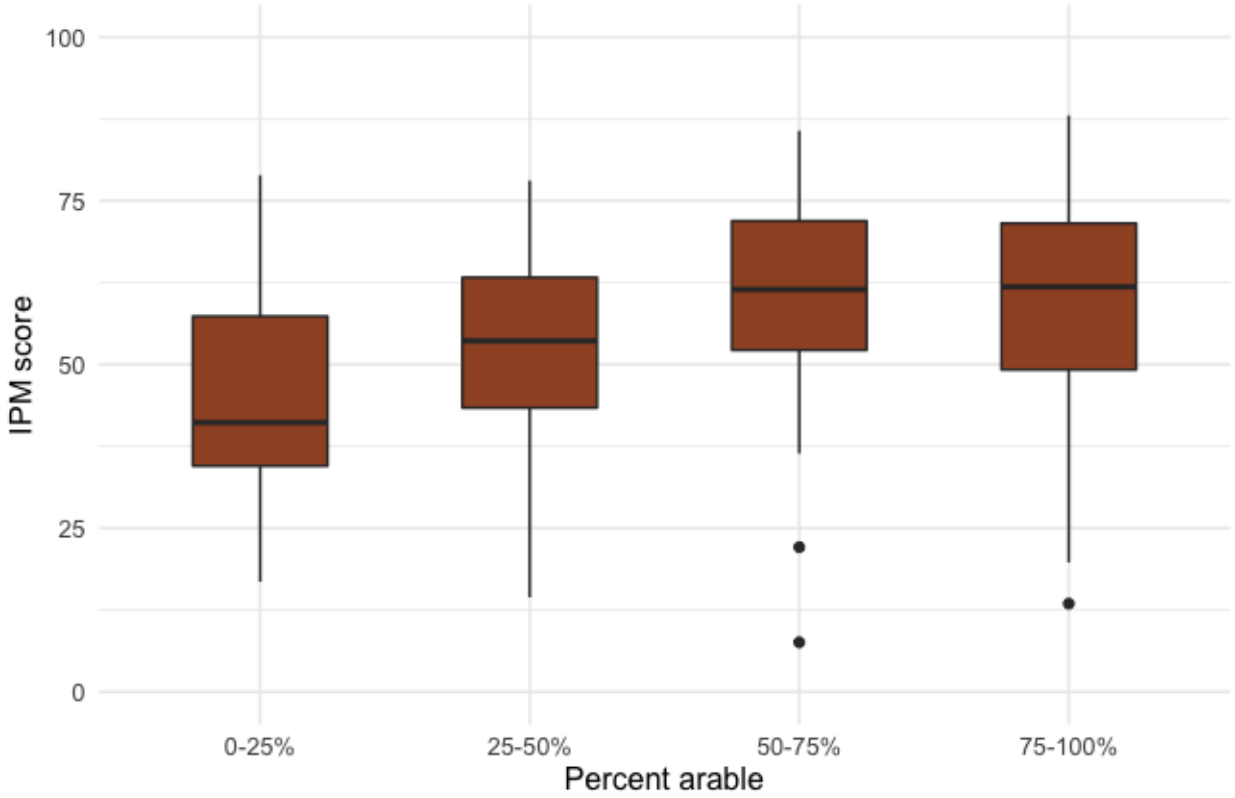

Figure 6 - IPM score in relation to the proportion of arable land farmed ($p<0.05$, Appendix 2).

5.2.4 Biodiversity scheme

Those involved in a biodiversity scheme typically had higher IPM scores (Table 7a). The most popular scheme was the Scottish government's Agri-Environment Climate Scheme (AECS). Farmers who are members of Linking Environment And Farming (LEAF) often achieved higher IPM scores (Table 7b). This finding is unsurprising as LEAF heavily promotes IPM and LEAF farmers are required to demonstrate the uptake of IPM practices at their annual audits. LEAF was the only scheme which requires payment for membership whereas for all other schemes farmers receive payment for joining.

Table 7a7 - Participation in Biodiversity Scheme

Biodiversity scheme	Total responses	Percent	Mean IPM Score
Don't know (DNRO)	3	1%	58.4
No	219	67%	56.0
Yes	107	33%	65.0

Table 7b - IPM scores by respondent biodiversity scheme

Biodiversity scheme	Total responses	Average IPM score	St. Dev. IPM score
Agri Environment Climate Scheme (AECS)	56	58.5	15.4
*Other	18	63.5	15.1
Linking Environment And Farming (LEAF)	10	76.0	3.9
In a scheme but don't know which one	6	61.6	16.1
NOTE: Only includes farmers who stated that they are involved in a biodiversity scheme. *Other included: Forestry Grant Scheme, sustainable cattle grant scheme, Royal Society for the Protection of Birds (RSPB), Scottish Rural Development Programme Statistically significant p = 0.008.			

5.3 Perceived pest threats

Perceptions on the key pests varied by profession (farmer/agronomist) (Table 8). Farmer and agronomist perceptions on the greatest pest threats aligned on slugs, leatherjackets and blackgrass (Table 8). Slugs are considered the main pest of concern in Scotland. The damp, cool environments across much of Scotland are optimal for slugs. There is a general lack of natural predation and the only slug pellets currently available now (ferric phosphate) are sometimes less effective than the recently banned metaldehyde, and ineffective at reduced doses (whereas this tactic was possible with metaldehyde). Leatherjackets are more a concern in areas with grass in the rotation (i.e. mixed farms). Leatherjackets have been more difficult to control since the pesticide that was used to control them (active ingredient: chlorpyrifos) was withdrawn from use in 2016. The concern around blackgrass (*Alopecurus myosuroides*) is likely fuelled by the significant issues experienced when attempting to manage this grass weed in England.

Agronomists perceived diseases such as Septoria and Ramularia, of wheat and barley respectively, to be a greater threat to production than farmers did (Table 8b). This is likely because many agronomists are fully responsible for managing diseases and are therefore more likely to be aware of the management issues and available solutions. Accurate disease identification often requires a higher level of diagnostic skills than is required for weeds and invertebrate pests, which some farmers may lack. Agronomists are also required to stay up to date with changes in varietal resistance and fungicide efficacy as they devise the management strategy.

It is probably of concern that 25 arable farmers were 'Unsure' as to what the current pest threats are (Table 8a). This could indicate that they are unaware because they have given their agronomist sole responsibility for making crop protection decisions. Ideally decisions would be shared.

Table 8a - Greatest perceived pest threats ordered according to arable farmer responses.

Pest	Arable Farmer	Agronomist
Slugs	26.4% (n=72; rank = 1st)	33.3% (n=9; rank = 2nd)
Couchgrass	14.7% (n=40; rank = 2nd)	Did not mention
Leatherjackets	12.5% (n=34; rank = 3rd)	14.8% (n=4; rank = 8th)
Unsure *	9.2% (n=25; rank = 4th)	Did not mention
Blackgrass	8.8% (n=24; rank = 5th)	25.9% (n=7; rank = 4th)
Dockens	7.3% (n=20; rank = 6th)	Did not mention
Cabbage Stem Flea Beetle	7.0% (n=19; rank = 7th)	7.4% (n=2; rank = 16th)
Thistles	7.0% (n=19; rank = 8th)	Did not mention
Chickweed	6.6% (n=18; rank = 9th)	3.7% (n=1; rank = 38th)
Mildew	6.2% (n=17; rank = 10th)	Did not mention
*Nearly all respondents who answered "unsure" receive information primarily from an agronomist.		

Table 8b - Greatest perceived pest threats ordered according to agronomist responses.

Pest	Agronomist	Arable Farmer
Septoria	37.0% (n=10; rank = 1st)	5.13% (n=14; rank = 17th)
Slugs	33.3% (n=9; rank = 2nd)	26.37% (n=72; rank = 1st)
Ramularia	29.6% (n=8; rank = 3rd)	6.23% (n=17; rank = 11th)
Blackgrass	25.9% (n=7; rank = 4th)	8.79% (n=24; rank = 5th)
Aphids	22.2% (n=6; rank = 5th)	5.86% (n=16; rank = 13th)
Nematodes	18.5% (n=5; rank = 6th)	4.40% (n=12; rank = 22nd)
PCN	18.5% (n=5; rank = 7th)	5.13% (n=14; rank = 16th)
Leatherjackets	14.8% (n=4; rank = 8th)	12.45% (n=34; rank = 3rd)
Yellow rust	14.8% (n=4; rank = 9th)	0.37% (n=1; rank = 41st)
Barren brome	11.1% (n=3; rank = 10th)	4.03% (n=11; rank = 23rd)

5.4 Perceptions on effective control measures

Agronomists and arable farmers perceived varietal resistance to be the most effective method of controlling disease (Table 9a). However, resistant varieties may not be adopted to the level they are perceived to be as differences can exist between actual and perceived practices i.e. farmers may believe they are practising IPM, e.g. by growing a disease resistant variety, when in reality they are not as the variety's weaknesses may be masked by the effect of fungicides (Stetkiewicz S. et al. 2018). Farmers and agronomists perceived all measures to be equally effective at controlling invertebrate pests (Table 9b).

Table 9a -Measures for controlling diseases ranked. 1=most effective, 4=least effective.

Disease	Farmer ranking	Agronomist ranking
None - all equally effective	1.81	-
Varietal resistance	1.95	1.31
Rotation	2.24	2.42
Fungicides	2.43	2.40
Cultivations	3.23	3.81

Table 9b - Measures for controlling invertebrate pests ranked. 1=most effective, 4=least effective.

Pest	Farmer ranking	Agronomist ranking
None - all equally effective	1.61	1.61
Cultivations	2.36	2.36
Rotation	2.40	2.40
Pesticides	2.50	2.50
Varietal resistance	2.61	2.61

5.5 Agronomist influence

Farmers who did not consult an agronomist scored significantly lower for IPM adoption than those who used an agronomist ($p<0.001$ Appendix 2). This finding further highlights the key role the agronomist plays in encouraging IPM adoption. Agronomists were classified as 'independent', if pay is unrelated to sales, or 'dependent' if pay is related to sales wither by salary or commission. Dependent agronomists were more commonly used than independent agronomists (Table 10). There was no overall significant differences in clients (farmers) IPM scores between agronomists classed as dependent or independent. Farm type (arable specialist/mixed) had no influence on type of agronomist used (independent or dependent). Agronomist companies differ in their geographical range and, as a result of the cropping land being largely in the east of the country, degree of specialism in arable crops (Table 10a, b).

Table 10a - Dependent agronomist (pay linked to sales) groups and their clients IPM scores

Agronomist group (anonymised)	Total respo -nses	Mean IPM Score	Std. Dev IPM Score	Mean Farmer Age	Mean percent arable	Region
Dependent 1	53	62.5	14.8	58.6	78%	Eastern Scotland (30.2%) Highlands and Islands (15.1%) North Eastern Scotland (26.4%) Other (26.4%) South Western Scotland (1.9%)
Dependent 2	16	61.5	13.4	59.6	90%	Eastern Scotland (38%) Highlands and Islands (12%) North Eastern Scotland (25%) Other (25%)
Dependent 3	12	60.7	13.2	54.4	76%	Highlands and Islands (16.7%) North Eastern Scotland

						(58.3%) Other (25.0%)
Dependent 4	26	60.6	16.2	57.7	65%	Eastern Scotland (12%) Highlands and Islands (23%) Other (23%) South Western Scotland (42%)
Dependent 5	14	55.2	8.4	53.6	79%	Eastern Scotland (7.1%) Highlands and Islands (14.3%) North Eastern Scotland (28.6%) Other (50.0%)

Table 10b - Independent (pay unrelated to sales) agronomist groups and their clients IPM scores

Agronomist group (anonymised)	Total respo -nses	Mean IPM Score	Std. Dev IPM Score	Mean Farmer Age	Mean percent arable	Region
Independent 1	20	72.7	6.9	50.6	77%	Eastern Scotland (75.0%) North Eastern Scotland (10.0%) Other (15.0%)
Independent 2	6	63.7	9.9	57.7	91%	Eastern Scotland (50%) North Eastern Scotland (33%) Other (17%)
Independent 3	14	59.4	12.4	59.6	74%	Eastern Scotland (21.4%) Highlands and Islands (14.3%) North Eastern Scotland (14.3%) Other (35.7%) South Western Scotland (14.3%)
Independent 4	6	58.0	10.8	67.2	85%	Eastern Scotland (50%) North Eastern Scotland (50%)
Independent 5	10	57.2	11.6	62.5	75%	Eastern Scotland (50%) North Eastern Scotland (10%) Other (40%)

5.6 Information sources & Farmer Networks

Agronomists and arable farmers acquire IPM knowledge from a range of information sources the most popular being their peers, research organisations, farming press, levy boards and professional memberships (Figure 7, Table 11). Agronomists are more likely to use social media than farmers, whereas farmers are more likely to gain IPM information from the farming press (Table 11). Agronomists are also more likely to acquire information from pesticide product manufacturer representatives who less frequently interact directly with farmers.

Knowledge of the IPM information network means that IPM messages can be delivered to farmers by channelling the information through their preferred sources (Creissen et al. 2021). Figure 7 shows a great deal of peer-to-peer interactions between farmers, and between farmers and agronomists. Interestingly more popular information sources (denoted by a larger node/circle) include several research organisations and several farming press outlets which highlights the significant role that both groups have in disseminating and promoting IPM messages.

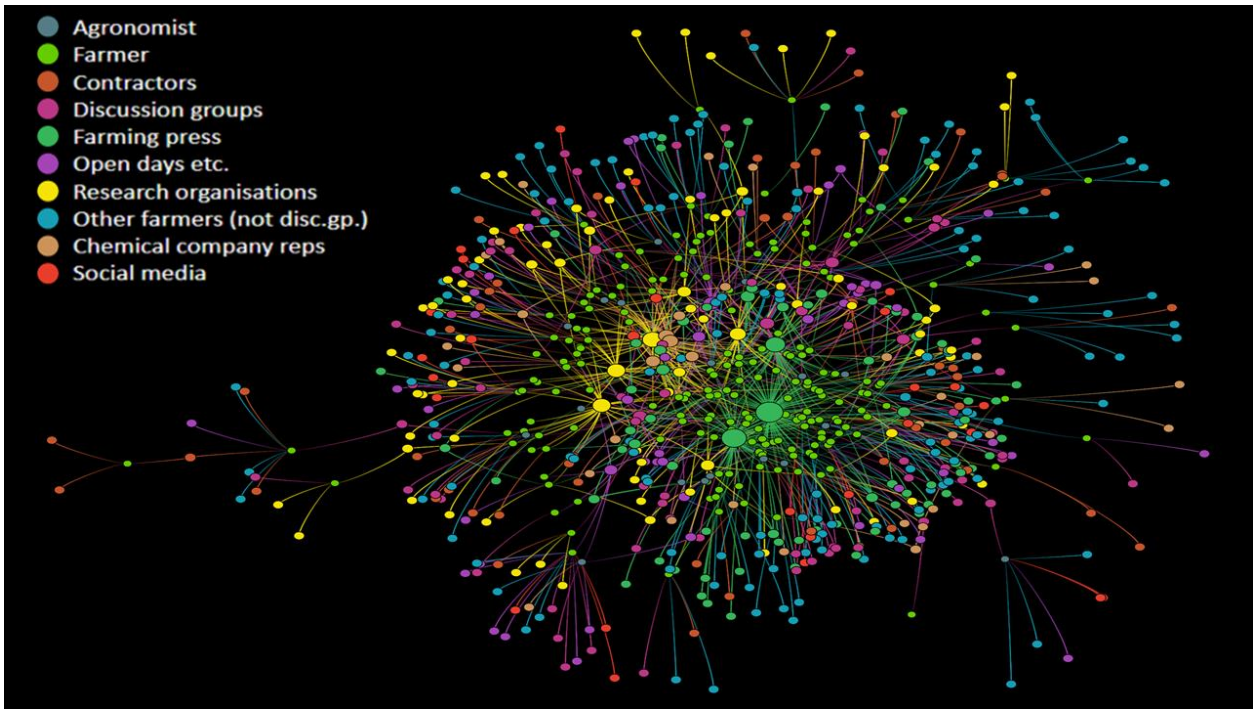

Figure 7 – Preferred IPM information sources of arable farmers and agronomists in Scotland. Each circle represents an actor (individual or an organisation). The size of the circle indicate its popularity. Circles that lay at the centre of the graph tend to be the most important and are the most connected. This implies that those groups at the centre (i,e. Farming Press) have the most control over how information flows in the network.

Table 11 –8 Popularity of IPM information sources with arable farmers and agronomists.

Information Source	Farmer	Agronomist
Other farmers (not including discussion groups)	68.9%	57.7%
Farmer discussion groups	60.3%	53.9%
Farming press	59.6%	30.8%
Information and updates from membership	46.1%	53.9%
Levy and research organisations	46.1%	53.9%
Open days/crop walks	43.5%	53.9%
Social media	30.3%	57.7%
Product manufacturer representative	26.2%	46.2%
Contractors	18.7%	19.2%
Respondents could choose all that apply.		

5.7 Barriers to further IPM uptake

The biggest single barrier to further IPM uptake was 'Time and effort required to increase knowledge of IPM' for farmers, and for agronomists it was 'Market constraints' (Table 12). The perception that IPM adoption always requires a significant amount of investment to upskill oneself has been perpetuated by many key stakeholders, yet many IPM measures are simple to understand and implement. Many arable farmers may already be practicing IPM to a high level without even knowing it as IPM. Making 'IPM farming' a less daunting task is something that all stakeholders can work together to improve. By presenting IPM as a programme of continual development in which IPM measures are added incrementally over time, and frequently evaluating their various costs and benefits, it may be possible to deter the notion that IPM is only for those who have the ample resources to invest in upskilling themselves and as a result encourage farmers to progress along the IPM continuum and achieve higher levels of uptake (Benbrook 1996; Lamine 2011).

Market constraints posed the biggest barrier for agronomists. This is likely related to the premiums, or an enhanced risk of market rejection attached to certain crops, largely those destined for human consumption as opposed to livestock. Agronomists are likely to be more acutely aware of the quality parameters and any changes in quality requirements, especially compared to farmers growing largely for the feed market. It could also be due to the perception that some IPM actions are more costly to implement or less reliable, compared to conventional methods that rely heavily on pesticides, and if that extra investment is not rewarded by attaining a higher price for the produce, then it makes certain IPM practices prohibitively expensive to implement. Impartial, independently acquired evidence on the effectiveness of IPM measures and advice on how to develop and optimise IPM solutions may help to 'de-risk' IPM in the eyes of the practitioner.

As fewer pesticides are registered for use in the UK or are removed due to environmental toxicity regulations and/or rendered ineffective due to high levels of pesticide resistance, alternative and integrated approaches to managing pests will become more attractive. A

greater understanding of the effectiveness of traditional methods, like crop rotation, and more recently developed IPM measures, such as biopesticides and enhanced monitoring, for certain pest situations may increase grower confidence in implementing certain IPM strategies by providing a better understanding of the relative risks. Recently, the effectiveness of IPM measures has been reviewed for cereals, oilseeds, and potatoes (Blake et al. 2021). The review identified gaps in the evidence, indicating that further research is required. Where the evidence that a particular IPM measure is effective and the potential for increased uptake is high then further KTE is required to promote such practices (Blake et al. 2021).

Table 12 - Barriers to further IPM uptake as identified by arable farmers and agronomists.

Barriers to IPM uptake	Farmer	Agronomist
*Other (please specify)	34.4% (n=66)	47.4% (n=9)
Time and effort required to increase knowledge of IPM	15.6% (n=30)	10.5% (n=2)
Don't know	13.5% (n=26)	0.0% (n=0)
Farm constraints (e.g. lack of suitable land for crop rotation)	11.5% (n=22)	5.3% (n=1)
Equipment costs	8.3% (n=16)	5.3% (n=1)
Labour costs	5.2% (n=10)	0.0% (n=0)
Risks associated with IPM	3.6% (n=7)	5.3% (n=1)
Lack of evidence for IPM	2.6% (n=5)	0.0% (n=0)
Low confidence in IPM	2.6% (n=5)	5.3% (n=1)
Market constraints	2.6% (n=5)	21.1% (n=4)
*Other included: limited variety of pesticides (10.6%), lack of knowledge (7.6%), limited varieties (6.1%), return on investment (6%), weather conditions (4.5%), customer demand (3.0%).		

6 Future research

The information networks generated in this project can allow for the development of more targeted knowledge transfer and exchange programmes, by targeting the farmers' preferred information sources, ensuring that the information is received by the intended audience.

More impartial and independently acquired evidence on the effectiveness of individual and combinations of IPM measures may increase grower confidence in implementing certain IPM strategies by providing a better understanding of the relative risks.

There are many factors that influence IPM uptake and pesticide usage e.g. local environmental conditions, specific crops grown, target market. Economics are often the main driver or barrier to both. To further understand the relationship between IPM uptake and pesticide usage, a significantly more detailed analysis that considers all aspects of the farm and farming business is required as understanding the real cost-efficiency of IPM strategies would require detailed context-specific data for a range of cropping systems over a gradient of IPM adoption, for different types of production situations.

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8 Appendix 1: IPM Questionnaire

Good morning/afternoon/evening. My name is … I'm calling from Ipsos MORI Scotland, the independent research organisation, on behalf of Scotland's Rural College.

We are conducting a short survey to understand the ways in which arable farmers in Scotland are practising Integrated Pest Management and the networks used to share information. The research is funded by the Plant Health Centre. Your participation will help guide policy decisions on how best to implement Integrated Pest Management practices in Scotland.

[ADD IF NECESSARY]

Integrated Pest Management is a whole farm approach to pest management that maximises productivity whilst minimising negative impacts on the environment. Individual businesses can take many different but appropriate approaches to practicing IPM. SRUC has adopted an IPM Assessment Plan previously used in England and Wales to understand IPM practices among Scottish farmers. The results of this survey will help SRUC to evaluate existing practices and help businesses improve and develop IPM planning.

[IF ASKED FOR CONTACT DETAILS]

- The contact at Ipsos MORI is Sally Abernethy, if you would like to find out more about the survey (0785 517 8925)
- The contact at SRUC is Elliot Meador (0131 535 4338).

Are you happy to proceed with the interview?

Yes 1 Go to Q1 or Make appointment

No 2 Go to CLOSE

Before we begin, I'd like to inform you that Ipsos MORI is a member of the Market Research Society. All information that you give us will be treated in the strictest confidence and your identity will not be passed on to a third party or connected to your answers in any way without your consent.

[ADD IF NECESSARY]

You can access our privacy policy at [PRIVACY NOTICE URL] or if you let me know your email address I can make sure that this will be sent to you within a week. The privacy policy explains the purposes for processing your personal data as well as your rights under data protection regulations to access your personal data, withdraw consent, object to processing of your personal data and other required information.

Screener

SHOW IF SAMPLE = ARABLE FARMER

Q1a. I need to speak with the owner or manager of the farm. Are you the best person to talk to?
READ OUT. SINGLE CODE.

Yes	1 (Continue to Q3)
No	2 (Ask to be transferred to correct person and return to consent Q)
Don't know (DNRO)	3 (Ask to be transferred to correct person and return to consent Q)

SHOW IF SAMPLE = AGRONOMIST

Q1ai. Are you currently working as an on-farm agronomist/crop adviser?
READ OUT. SINGLE CODE.

Yes	1 (Continue to Q1d)
No	2 (Ask to be transferred to correct person and return to consent Q)

Section 1: Introduction questions

SHOW IF SAMPLE = ARABLE FARMER

To begin, I'd like to ask some questions about you and your farm.

SHOW IF SAMPLE = AGRONOMIST

To begin, I'd like to ask some questions about you and your clients.

ASK ALL

Q3. Which of the following best describes how you think of yourself?
READ OUT. SINGLE CODE.

Male	1
Female	2
Or in another way?	3
Refused (DNRO)	4

ASK ALL

Q2. Please could you tell me your age at your last birthday?
WRITE IN NUMBER
Numeric range (16-99)

Don't know (DNRO)	2
Refused (DNRO)	3

INTERVIEWER – IF PARTICIPANT REFUSES, ASK IF WILLING TO SAY WHICH OF THE BELOW AGE BANDS AND ENTER AGE IN THE MIDDLE OF THAT BAND, E.G. IF THEY ARE BAND 45-54, ENTER 50.

16-29	1
30-40	2
41-54	3
55-64	4
65 and over	5
Refused (DNRO)	6

CREATE AGE VARIABLE USING GROUPS AS ABOVE, BUT FOR PURPOSE OF AGE QUOTA COMBINE CODES 1 AND 2 INTO 'UNDER 41'.

AGE QUOTAS GROUPS:

Under 41

41-54

55-64

Over 64

ASK IF SAMPLE = ARABLE FARMER

Q1b. Which of the following best describes your position on the farm?

READ OUT. SINGLE CODE.

Farm manager	1
Owner	2
Tenant	3
Crop protection decision maker	4

ASK IF SAMPLE = ARABLE FARMER

Q1c. What is the postcode sector of your farm? (That is the first three digits of your postcode).

IF REQUIRED: This is to give us a rough idea of the farm's location in Scotland.

WRITE IN

Refused

_____

ASK IF SAMPLE = ARABLE FARMER

Q4a. About how large is your farmed area?

Thinking first about the area you own, how many hectares do you own?

NOTE TO INTERVIEW. CHECK THAT PARTICIPANT HAS GIVEN AN ANSWER FOR BOTH OWNED AND RENTED LAND IF APPLICABLE. WRITE IN 0 IF ONE DOES NOT APPLY.

_____ owned

And how many hectares do you rent?

_____ rented

Don't know (DNRO)	1
Refused (DNRO)	2

ASK IF SAMPLE = ARABLE FARMER

Q5. And what percentage of the land you farm is arable?

WRITE IN NUMBER

RANGE 1-100%

IF LESS THAN 10% CLOSE SURVEY

IF RESPONDENT FINDS IT EASIER TO GIVE ACTUAL NUMBER OF HECTARES THAT ARE ARABLE, WRITE IN:

Don't know (DNRO)	1
Refused (DNRO)	2

ASK IF SAMPLE = ARABLE FARMER AND Q5a IS LESS THAN 100%

Q6b. Do you have any of the following livestock on your farm?

READ OUT. MULTICODE OKAY.

Dairy	1
Beef	2
Sheep	3
Pigs	4
Others (specify)	5
No livestock	6
Don't know (DNRO)	7
Refused (DNRO)	8

ASK IF SAMPLE = AGRONOMIST

Q1d. In what counties do the majority of your clients farm?

WRITE IN

ASK IF SAMPLE = AGRONOMIST

Q6d. How many clients do you have who produce arable crops?

WRITE IN NUMBER

Numeric range (1-500)

IF ANSWER IS 0 – CLOSE SURVEY

ASK IF SAMPLE = AGRONOMIST

Q6e. About how large is the total farming area covered by your clients in hectares?

WRITE IN NUMBER

NUMERIC RANGE (1-100,000)

Don't know (DNRO) 1

Refused (DNRO) 2

ASK IF SAMPLE = AGRONOMIST

Q6f. And what percentage of the land on your clients' farm is arable?

WRITE IN NUMBER

RANGE 1-100%

Don't know (DNRO) 1

Refused (DNRO) 2

ASK ALL

Q6a. What are the three most economically important crops [IF SAMPLE=ARABLE FARMER you grow] [IF SAMPLE=AGRONOMIST your clients grow]?

MULTICODE UP TO THREE. PROMPT TO PRECODES.

1 Barley - winter

2 Barley - spring

3 Beans - winter field beans

4 Beans - spring field beans

5 Beans - fresh broad beans

6 Beans - soyabeans

7 Beans - dwarf French beans

8 Beet - fodder

9 Beet - sugar
10 Borage
11 Brussel sprouts
12 Brocolli/calabrese
13 Cabbage
14 Carrot
15 Cauliflower
16 Clover - red clover
17 Clove - white clover
18 Fodder rape
19 Grass - sown in the last five years
20 Grass - over five years old
21 Grass - herbage seed
22 Grass - permanent pasture
23 Grass - rough grazing
24 Hemp
25 Kale
26 Leek
27 Linseed - winter
28 Linseed - spring
29 Lucerne
30 Lupin
31 Mangel
32 Maize for grain
33 Maize for forage or AD
34 Mixed corn for threshing
35 Mustard
36 Oats - winter
37 Oats - spring
38 Oilseed rape - winter
39 Oilseed rape - spring
40 Onion
41 Parsnip
42 Pea - combining dry pea
43 Pea- vining pea
44 Pea - edible podded
45 Potato - early
46 Potato - maincrop

47 Potato - seed
48 Rye - winter
49 Rye - spring
50 Sanfoin
51 Sunflower
52 Swede
53 Triticale - winter
54 Triticale - spring
55 Turnip
56 Wheat - winter
57 Wheat - spring
58 Wheat - durum
59 Wheat – spelt
60 Other

ASK IF SAMPLE = ARABLE FARMER

Q 2c. Do you have any off-farm work experience that is relevant to farming or agriculture?

Yes	1
No	2
Unsure	3
Refused (DNRO)	4

ASK IF SAMPLE = AGRONOMIST

Q2f. How many years have you worked as an agronomist?

WRITE IN NUMBER

Numeric range (1-99)

Don't know (DNRO)	2
Refused (DNRO)	3

ASK IF SAMPLE = AGRONOMIST

Q2g. Are you also a farmer?

SINGLE CODE.

Yes	1
No	2
Unsure	3
Refused (DNRO)	4

ASK ALL

Q2d. Do you have a farming qualification? IF YES, ASK What qualification is that?

READ OUT IF NECESSARY. MULTICODE OKAY.

None	1
NRoSO	2
BASIS/ FACTS	3
National Diploma	4
Bachelor's degree	5
Higher degree	6
Other (specify)	7
Refused (DNRO)	8

ASK IF SAMPLE = ARABLE FARMER

Q2e. Are you involved in a scheme or initiative that promotes biodiversity such as an agri-environment scheme? For example, AECS, supply chain initiatives or LEAF.

SINGLE CODE

Yes *(please state)*	1
No	2
Don't know (DNRO)	3
Refused (DNRO)	4

ASK ALL

Q7. How familiar are you with Integrated Pest Management (IPM)?

READ OUT. SINGLE CODE.

Not at all familiar	1
Somewhat unfamiliar	2
Moderately familiar	3
Familiar	4
Very familiar	5
Refused	6

Section 2: IPM Metric

SHOW IF SAMPLE = ARABLE FARMER

The next set of questions are about practices relating to Integrated Pest Management.

ASK IF SAMPLE = ARABLE FARMER

Q8. What percentage of the farm land is in continuous barley or winter wheat production? By continuous, we mean growing barley or winter wheat on the same land for five or more consecutive years without growing a non-cereal break crop (such as oilseed rape, beans, peas, grass).

READ OUT. SINGLE CODE.

None	1
Less than 25%	2
25-49%	3
50-74%	4
75%-or more	5
Don't know (DNRO)	6
Refused (DNRO)	7

ASK IF SAMPLE = ARABLE FARMER

Q9a. Do you typically use an arable rotation system on your farm?

Yes	1 (Go to Q9b)
No	2 (Skip to Q10)
Don't know (DNRO)	3 (Skip to Q10)
Refused (DNRO)	4 (Skip to Q10)

ASK IF CODE 1 AT Q9a

Q9b. [ARABLE FARMER Thinking about your farm] to what extent do you agree or disagree with the following reasons for using arable rotation…?

READ OUT. RANDOMISE ORDER. SINGLE CODE PER ROW.

		Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly agree	Don't know (DNRO)	Refused (DNRO)
A	to control weeds	1	2	3	4	5	6	7
B	to control disease	1	2	3	4	5	6	7

C	to control insect pests, nematodes, slugs and snails	1	2	3	4	5	6	7
D	to improve or maintain soil structure and fertility	1	2	3	4	5	6	7
E	to spread costs and financial risks	1	2	3	4	5	6	7
F	to comply with a scheme or contractual obligations	1	2	3	4	5	6	7

ASK ALL WHERE MORE THAN ONE CROP SELECTED AT Q6a

Q10a. Which of [IF ARABLE FARMER your crops] [IF AGRONOMIST your clients' crops] would you consider to be the most economically important?

NOT TO INTERVIEW: If participant says grass and there are other non-grass crops listed below, ask participant to choose between those instead.

[SHOW LIST OF CROPS SELECTED AT Q6a

[SKIP IF ONLY ONE CROP SELECTED AT Q6a]

ASK ALL

Q10c. [SHOW THIS QUESTION WORDING IF SAMPLE = ARABLE FARMER] What influences your choice of [INSERT CROP SELECTED AT Q6a or Q10a] variety?

[SHOW THIS QUESTION WORDING IF SAMPLE = AGRONOMIST] What influences the advice you give on the [INSERT CROP SELECTED AT Q7] crop varieties to grow?

Please choose up to three of the following in order of preference. I will read out the full list first.

READ OUT. RANDOMISE ORDER. SINGLE CODE PER COLUMN.

	Rank 1	Rank 2	Rank 3
Recommended lists (where available)			
Availability of seed			
Price of seed			
Adviser recommendation			
End-market			
Disease resistance			
Weed competitiveness			

Yield potential			
Quality potential			
Consistency of performance			
Insect pest tolerance / resistance			
Other (Please specify below)			
None of the above	Skip 2-3	Skip 3	
Don't know (DNRO)			
Refused (DNRO)			

ASK IF SAMPLE = ARABLE FARMER

Q11. Which of the following management measures do you currently employ to control the introduction and spread of pests on the land that you farm or manage?

A. Firstly, thinking about prevention of weed problems, which – if any– of the following techniques apply to your farm…

READ OUT. RANDOMISE ORDER. MULTICODE OKAY.

Stale/false seedbeds

Full inversion ploughing

Only employing non-inversion tillage when other cultural measures to reduce weed numbers are adopted

Optimal timing for control measures

Patch spraying of weeds with a selective herbicide (including precision farming) or weed-wiper

Hand rogueing, mechanical or chemical crop and weed destruction

Manage cropped headlands to prevent weed ingress from non-cropped areas

Regular cleaning of equipment and/or fields with high weed levels are harvested last

Crop inspections

Other (specify) – do not rotate

None of these – do not rotate

Don't know (DNRO) – do not rotate

Refused (DNRO) – do not rotate

B. And now thinking about disease control, which – if any – of the following apply to your farm…

READ OUT. RANDOMISE ORDER. MULTICODE OKAY.

Growing resistant varieties

Use of certified seed

Testing of non-certified seed and treatment if required

Regularly testing soils for soil borne pathogens

Use of seed treatments where available

Crop inspections

Other (specify) – do not rotate

None of these – do not rotate

Don't know (DNRO) – do not rotate

Refused (DNRO) – do not rotate

C. And now thinking about control of insects, nematodes and slugs, which – if any – of the following apply to your farm…

READ OUT. RANDOMISE ORDER. MULTICODE OKAY.

Encouraging beneficial insects through provision of habitats

Minimising use of broad-spectrum insecticides

Use of seed treatments

Cultivations for control of slugs

Regularly monitoring above ground pest populations

Setting action thresholds

Regularly testing soils for nematodes

Regularly testing soils for insect pests

Frequently cleaning harvesting, cultivating and storage equipment

Crop inspections

Other (specify) – do not rotate

None of these – do not rotate

Don't know (DNRO) – do not rotate

Refused (DNRO) – do not rotate

ASK IF CROP INSPECTIONS SELECTED AT Q11A

Q11Ai. How frequently do you conduct crop inspections to prevent weeds during the relevant times of the year?

READ OUT. SINGLE CODE.

Weekly or more often	1
Every two weeks	2
Monthly	3
Don't know (DNRO)	4
Refused (DNRO)	5

ASK IF CROP INSPECTIONS SELECTED AT Q11B

Q11Bi. How frequently do you conduct crop inspections to control disease during the relevant times of the year?

READ OUT. SINGLE CODE.

Weekly or more often	1
Every two weeks	2
Monthly	3
Don't know (DNRO)	4
Refused (DNRO)	5

ASK IF CROP INSPECTIONS SELECTED AT Q11C

Q11Ci. How frequently do you conduct crop inspections to control insects, nematodes and slugs during the relevant times of the year?

READ OUT. SINGLE CODE.

Weekly or more often	1
Every two weeks	2
Monthly	3
Don't know (DNRO)	4
Refused (DNRO)	5

ASK IF CODE 2-6 AT Q7

Q12. Which, if any, of the following factors do you consider when developing (IF ARABLE FARMER your] [IF AGRONOMIST your clients') integrated pest management (IF ARABLE FARMER plan] [IF AGRONOMIST plans)?

READ OUT. RANDOMISE ORDER. MULTICODE OKAY.

Crop walking data from last season, used to assess the performance of various control measures
Technical research on plant protection product efficacy and efficacy of cultural control measures
Weed maps, created and monitored for changes between seasons
Yield maps or information, used to identify areas requiring specific attention
Cost-benefit analysis of management options
End-market requirements
Variety resistance
Soil borne diseases, nematodes and insects (including slugs)
Position of each individual crop in your planned rotation
Pesticide anti-resistance strategies
Other (please specify) – do not rotate
None of the above – do not rotate

This is the first time I have completed a formal plan (DO NOT SHOW FOR AGRONOMIST SAMPLE) – do not rotate
Don't know (DNRO) – do not rotate
Refused (DNRO) – do not rotate

ASK IF CODES 2-6 AT Q7

Q13a. Please rank the following measures according to their effectiveness in controlling disease. RANK 1 TO 4 (OR 5 IF 'OTHER' specified). READ OUT…

- ☐ Varietal resistance
- ☐ Rotation
- ☐ Cultivations
- ☐ Fungicides
- ☐ Others, please specify _____
- ☐ None – all equally effective
- ☐ Don't know
- ☐ Refused

ASK IF CODES 2-6 AT Q7

Q13b. Please rank the following measures according to their effectiveness in controlling invertebrate pests (such as insects and slugs etc.). RANK 1 TO 4 (OR 5 IF 'OTHER' specified). READ OUT….

- ☐ Varietal resistance
- ☐ Rotation
- ☐ Cultivations
- ☐ Pesticides
- ☐ Others, please specify _____
- ☐ None – all equally effective
- ☐ Don't know
- ☐ Refused

ASK ALL

Q13c. [SHOW THIS QUESTION WORDING IF SAMPLE = ARABLE FARMER] Which of the following are the THREE most important that factors influence your decision to adjust your spray programme (e.g. changes in timings, rates, products) throughout the season?

[SHOW THIS QUESTION WORDING IF SAMPLE = AGRONOMIST] In general, what are the three most important factors that influence your decision to suggest adjusting spray programmes (e.g. changes in timings, rates, products) throughout the season?

MULTICODE UP TO 3. READ OUT

	Factor
Growth stage of the crop	
Crop economic potential	
Calendar date	
Resistance management	

Weather conditions and forecasts	
Industry crop monitoring information (e.g. aphid/disease alerts)	
Predictions of Decision Support Systems (where available)	
Availability of plant protection products	
Lack of availability of plant protection products	
Observed levels of pest/weed/disease presence in the field (including thresholds)	
BASIS qualified agronomist recommendation	
Actions of or advice from other farmers in the area	
None of the above, I operate a fixed spraying programme	
Don't know Refused	

ASK ALL

Q13d. Are there any other important factors that influence your [ARABLE FARMER decision] [AGRONOMIST suggestion] to adjust the spray programme?

WRITE IN…….

ASK ALL

Q13ei. Please name the specific weeds, diseases, insect, nematode or slug pests which you see as being of the greatest **current** threat to crop production on the land that [ARABLE FARMER you farm] [AGRONOMIST your clients farm]. *PROBE: What else? NAME UP TO 5.*

	Current threat
1.	
2.	
3.	
4.	
5.	

ASK ALL

Q13eii. And now thinking about **in 5 years' time or more**, please name the specific weeds, diseases, insect, nematode or slug pests which you see as being of the greatest future threat to crop production on the land that **[ARABLE FARMER**

you farm] [AGRONOMIST your clients farm]. *PROBE: What else? NAME UP TO 5.*

	Future threat (5+ years' time)
1.	___
2.	___
3.	___
4.	___
5.	___

ASK ALL

Q15. What, if anything, is most preventing you from increasing uptake of IPM practices? PROBE TO PRECODES. SINGLE CODE.

Lack of evidence for IPM	1
Low confidence in IPM	2
Risks associated with IPM	3
Equipment costs	4
Labour costs	5
Time and effort required to increase knowledge of IPM	6
Farm constraints (e.g. lack of suitable land for crop rotation)	7
Market constraints	8
Other_____	9
Nothing/none of these	10
Don't know	11
Refused	12

Section 3: Random Name Generation

I am now going to ask you a series of questions about your social networks and how these might be used to help make decisions about Intergrated Pest Management on your farm. An important component that can impact on the adoption of IPM is where farmers, land managers and agronomists get their information from. We are going to ask you some details about that now. Please remember that the answers you give will be reported anonymously and won't be linked to any personally identifying information. You are free not to answer if you prefer.

ASK ALL

Q14. Which of the following would you look to for information regarding sustainable crop production practices on [IF ARABLE your farm] [IF AGRONOMIST your client's farms]?

READ OUT. MULTICODE OKAY.

SCRIPTER: CODE 10 VISIBLE TO ARABLE FARMER SAMPLE ONLY. CODES 11-15 VISIBLE TO AGRONOMIST SAMPLE ONLY.

Open days/crop walks	1
Farmer discussion groups	2
Other farmers (not including discussion groups)	3
Product manufacturer representative	4
Contractors	5
Farming press	6
Social media (e.g.Whatsapp, Facebook and Twitter)	7
Information and updates from membership, levy and research organisations	8
Online/Internet sources (such as Youtube etc.)	9
Agronomists	10
Agronomists within your company/association	11
Agronomists outisde your company/association	12
Training events organised by your company/association	13
Policy/regulation	14
Quality assurance scheme requirements	15
Other (please specify)	16
None of the above	17
Don't know (DNRO)	18
Refused (DNRO)	19

ASK IF CODE 10 AT Q14 (AGRONOMIST)

Q14a. Who is your agronomist?

WRITE IN

Don't know 2

Refused 3

ASK IF CODE 10 AT Q14 (AGRONOMIST)

Q14b. Who employs your agronomist?

WRITE IN

Don't know 2

Refused 3

WITH FOLLOWING, ASK MAX 4 FOLLOW UPS BASED ON RESPONSES GIVEN AT Q14. IF CODES 2-3 OR 7 SELECTED (FARMER DISCUSSION GROUPS, OTHER FARMERS, SOCIAL MEDIA) PRIORITISE THESE, THEN RANDOMLY FOLLOW UP ON ANY OTHERS TO MAX OF 4.

IF CODE 2 AT Q14

Q14_2 If you can, please name the discussion group(s) you receive information from…

OPEN TEXT BOX

Don't know

Refused

IF CODE 1 AT Q14

Q14_1 If you can, please name the open days or crop walks that you attended…

OPEN TEXT BOX

Don't know

Refused

IF CODE 3 AT Q14

Q14_3 If you can, please name up to three other farmers that you speak with…

OPEN TEXT BOX

Don't know

Refused

IF CODE 4 AT Q14

Q14_5 If you can, please name up to three product manufacturers with whom you speak…

OPEN TEXT BOX

Don't know

Refused

IF CODE 5 AT Q14

Q14_6 If you can, please name up to three contractors with whom you speak…

OPEN TEXT BOX

Don't know

Refused

IF CODE 6 AT Q14

Q14_7 If you can, please name up to three sources of farming press that you get information from…

OPEN TEXT BOX

Don't know

Refused

IF CODE 7 AT Q14

Q14_8 If you can, please name up to three people on social media you receive information from…

OPEN TEXT BOX

Don't know

Refused

IF CODE 8 AT Q14

Q14_9 If you can, please name up to three organisations you receive information from…

OPEN TEXT BOX

Don't know

Refused

9 Appendix 2: Factors influencing IPM scores

Dependent variable = IPM score. F statistics are shown for each model. P values are shown below in brackets.

	Model 1	Model 2	Model 3	Model 4
Age (coded numeric)	-0.443***	-0.371***	-0.355***	-0.314***
	(0.000)	(0.000)	(0.000)	(0.000)
Education (No education is reference category)				
National Diploma		8.791***	7.880***	5.179*
		(0.000)	(0.001)	(0.015)
Bachelor's Degree		6.810*	4.968+	3.309
		(0.026)	(0.096)	(0.228)
Higher Degree		4.521	2.788	3.515
		(0.328)	(0.541)	(0.402)
Region (Eastern Scotland is reference category)				
Other			-3.401	-1.719
			(0.160)	(0.444)
Northeastern Scotland			-7.023**	-6.620**
			(0.006)	(0.005)
Southwestern Scotland			-12.233***	-5.664+
			(0.000)	(0.071)
Highlands and Islands			-9.854**	-7.113*
			(0.004)	(0.027)
Agronomist type (Other is reference category and includes no-one, n/a, refused to answer)				
Independent agronomist				9.734***
				(0.000)
Dependent agronomist				9.264***
				(0.000)
Proportion of farm that is arable				6.907*

				(0.038)
Grass is one of their three most economically important crops				-8.183***
				(0.000)
Num.Obs.	276	276	276	271
R2	0.121	0.171	0.233	0.367
R2 Adj.	0.118	0.159	0.210	0.337
F	37.848	14.013	10.118	12.454
+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001				

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