Chaplin, Stephen, Mills, Jane ORCID logoORCID: https://orcid.org/0000-0003-3835-3058 and Chiswell, Hannah Marie ORCID logoORCID: https://orcid.org/0000-0003-4504-1319 (2021) Developing payment-by-results approaches for agri-environment schemes: Experience from an arable trial in England. Land Use Policy, 109. Art 105698. doi:10.1016/j.landusepol.2021.105698

Official URL: https://doi.org/10.1016/j.landusepol.2021.105698
DOI: http://dx.doi.org/10.1016/j.landusepol.2021.105698
EPrint URI: https://eprints.glos.ac.uk/id/eprint/10162

Developing payment-by-results approaches for agri-environment schemes: Experience from an arable trial in England

S.P. Chaplin a , J. Mills b,* , H. Chiswell b

a Natural England, Foss House, King's Pool, 1–2 Peasholme Green, York YO1 7PX, UK

b Countryside and Community Research Institute, University of Gloucestershire, Cheltenham GL50 4AZ, UK

* Corresponding author. E-mail address: jmills@glos.ac.uk (J. Mills).

Abstract

There is increasing interest in the potential for payment-by-results approaches to be adopted more widely in agri-environment schemes to address some of the limitations of conventional action-based approaches. To date, researchers have almost exclusively applied the approach in grassland farming systems. This paper reports on the results from an English, pure payment-by-results pilot scheme that tested the delivery of two environmental objectives: provision of winter bird food for farmland birds and provision of pollen and nectar resources for pollinating insects in arable farming systems, and incorporated farmer self-assessments. The method employed an assessment of environmental outcomes using an experimental design, recording the number of plants/seed heads per quadrat for specified species and an analysis of farmers' attitudes using a qualitative survey. The results from 15 farms revealed improved environmental performance compared to similar measures implemented under conventional agri-environment schemes. The analysis also revealed a high correlation of farmer self-assessment of results with expert assessments. Survey findings also identified farmers' views on the advantages (flexibility and freedom, fairness) and disadvantages (risk of failure and non-payment) of such an approach.

Keywords: Results-based agri-environment payment schemes, Farmer behaviour, self-assessment Risk preferences

1. Introduction

There is increasing interest across Europe in the potential for the adoption of payment-by-results (PBR) approaches in agri-environment schemes (AES) to help address some of the limitations of conventional action-based approaches. At the European level, the European Union Biodiversity Strategy 2030 (European Commission, 2020) explicitly refers to PBR approaches to deliver significant enhancement of the environment.

Concerns have been raised about the effectiveness of traditional AES and the limitations of a 'one-size-fits-all' approach to management prescriptions/payment (Reed et al., 2014; Batáry et al., 2015). This has led to an interest in more 'innovative' methods, including PBR. The key principle of PBR is the financial reward for defined environmental outcomes and represents a significant departure from conventional action-based approaches, which require participants to demonstrate the implementation of specific management actions (prescriptions).

Across Europe, the PBR approach has been deployed in several small-scale cases since the turn of the century. Although as Burton and Schwarz, and Schroeder et al. identified in 2013, and Chaplin et al. suggest was still the case in 2019, this work has focused largely on plant species in grassland systems as indicators of biodiversity (see for example, Buckingham et al., 1998; Oppermann and Briemle, 2002; Scottish Natural Heritage, 2005; Wittig et al., 2006; Klimek et al., 2008; Matzdorf et al., 2009; Hoft ¨ et al., 2010; Kaiser et al., 2010; Russi et al., 2016; Byrne et al., 2018; Maher et al., 2018; Dunford and Parr, 2020). There is only one known example of a PBR scheme in the context of an arable system, where crops are grown on an annual basis rather than continuously (Kreis Soest, 2016). This is a significant gap as a recent report by the European Court of Auditors (2020) identified arable farmers are less likely to commit to biodiversity-relevant agri-environment measures than other farm types. Furthermore, arable areas are experiencing significant biodiversity decline. In an English context, the farmland bird index (FBI), which measures populations of species strongly associated with farmland, including arable land, declined by 59% between 1970 and 2018 (Defra, 2020c), with much of this decline being driven by specialist granivorous (seed-eating) species making these a major focus of conservation effort. A similar index measuring the distribution of pollinating insects declined by 30% between 1980 and 2017 (Defra, 2020a). Declines in forage availability, especially in agricultural landscapes, are thought to be a major contributing factor (Carvell et al., 2006).

With this context in mind, this paper seeks to make a timely, empirical contribution to the discussions on the value of PBR by reporting on the results from a three-year pilot project in the South-East of England that focused on arable farming systems. The pilot tested two environmental objectives: provision of winter bird food for farmland birds and provision of pollen and nectar resources for pollinating insects. The central aim of the paper is to assess the effectiveness of a PBR approach in an arable context, and is supported by the following objectives:

- To assess the environmental performance of habitats under arable PBR agreements
- To assess the accuracy of farmer self-assessment of results
- To explore agreement holder and stakeholder attitudes to an arable PBR

In 2013, Burton and Schwarz made an appeal in the pages of this journal for more empirical studies on PBR approaches, contending a ‘jump’ into such provision without better understanding would be a mistake. If their appeal alone was not sufficient impetus for this work, increasing interest in the PBR approach in UK and across Europe further highlights its importance. For example, the UK government has committed to the notion of ‘payment for public goods’, via a new environmental land management system (ELM). PBR approaches are being considered alongside more conventional payment methodologies, such as government and market-based price setting, particularly for certain outputs where tested and proven to be feasible (Defra, 2020b). As such, the remainder of the paper is as follows; firstly, we provide a review of the key literature on the concept of PBR, its evolution, opportunities, and challenges. Following this, we detail the PBR pilot design and research methodology before presenting the results. The discussion considers the implications of a PBR approach to environmental performance and behavioural change and the potential value to the AES policy landscape and suggests priorities for further research

2. Payment-by-results: an overview

As Burton and Schwarz (2013) note, there are several different terms used to denote the concept of PBR in the literature, including ’result-oriented’, ’success-oriented’, ’objective-driven’, ’performance payment’ ’outcome-based/oriented’. Despite what they describe as an “unnecessarily varied nomenclature” (p. 630), Burton and Schwarz : 630) (2013) suggest they all refer to the same thing:

> “agri-environmental schemes that pay land managers, not for performing specific management actions (such as mowing on set dates or restricting fertiliser use to set limits), but for achieving set environmental outcomes (such as particular species mixes or the promotion of an endangered species)”

Although not widely implemented, the concept of PBR is not new. Increasing policy interest in PBR broadly emanates from the perceived failures of action-oriented approaches in Europe, including their economic and environmental ineffectiveness (Kleijn and Sutherland, 2003; Kleijn et al., 2006; Reed et al., 2014; Batáry et al., 2015; Byrne et al., 2018) and simultaneous failure to facilitate significant attitudinal change amongst farmers (Musters et al., 2001). The European Court of Auditors (ECA, 2011) raised concerns regarding the controllability of management actions resulting in additional evidence and record-keeping requirements for farmers culminating in a system that the Department of Environment, Food and Rural Affairs (Defra) in UK has, itself, come to identify as "burdensome, inflexible and too focused on punitive actions rather than improvement" (Defra, 2020b: 33).

Furthermore, strengthening of the neoliberalism project in Europe, and the associated belief that the competitive market has the potential to deliver environmental outcomes, is also understood to have fuelled interest in the concept (Burton and Schwarz, 2013).

Four key strengths of PBR approaches have been identified compared to action-based schemes with similar objectives.

Firstly, the link between payments and results gives farmers control and responsibility for delivering specific environmental outcomes using their own choice of management practices, increasing a sense of agency, which is thought to promote behavioural change and lead to improved outcomes (Burton and Paragahawewa, 2011; Burton and Schwarz, 2013; Staley, 2018; Wezel et al., 2018).

Secondly, the PBR approach gives farmers the flexibility to achieve outcomes in their specific location as they see fit, allowing them the freedom to use their own local knowledge and expertise (Klimek et al., 2008; Zabel and Roe, 2009). This flexibility helps to make environmental management an integral part of the farming system and farm business, rather than a set of land management ‘rules’ to be followed (Herzon et al., 2018). The absence of prescriptions provides flexibility at the field, farm, local, and regional level, rather than a national ‘one-size-fits-all’ set of prescriptions and allows innovation and experimentation (Burton and Schwarz, 2013; Dunford and Parr, 2020; O’Rourke and Finn, 2020).

Thirdly, the PBR approach offers an opportunity to simplify schemes focused around objectives (removing separate supplements and capital items as these become embedded in the delivery of objectives rather than separate payment items). There is no need for evidence that multiple prescriptions have been met as payment is based on results, not inputs/actions (Matzdorf and Lorenz, 2010; Russi et al., 2016).

Finally, as payment is only made when results are delivered, the cost-effectiveness of schemes can be improved. For example, Matzdorf and Lorenz (2010) reported a positive impact on cost-effectiveness compared to a conventional approach for a results-based scheme in Germany. If payments are structured effectively, farmers may be motivated to achieve higher environmental outcomes to secure higher payment rates (Wätzold and Drechsler, 2005; White and Sadler, 2012; Schroeder et al., 2013).

Although the PBR approach has been widely advocated (Oppermann and Briemle, 2002), its development is not without its challenges, in part evidenced by the lack of widespread adoption. As Schroeder et al. (2013, 133) note, “a major requirement for the successful implementation of this approach is the need to define indicators for the desired ecological goods”. Keenleyside et al. (2014) suggest that for biodiversity outcomes, indicators need to satisfy 7 criteria:

1. be representative of the target habitat or species;
2. occur consistently in target farmland habitats in the area;
3. be easily identified by farmers and paying agency representatives;

4. be measurable using a simple methodology;
5. be sensitive to changes in agricultural management but otherwise stable;
6. be unlikely to be influenced by external factors beyond the control of the land manager; and
7. not be achieved easily by means other than agricultural management.

Furthermore, farmers' attitudes to a comparatively greater degree of risk/reward sharing (Stolze et al., 2015) and the environmental advisory capacity to support delivery could be significant barriers to the adoption of a PBR approach. The practicalities (and expense) of monitoring and verification represents another key challenge of PBR (Burton and Schwarz, 2013), although empirical research broadly suggests farmers are capable of carrying out this role via self-assessment where indicators are well-designed and training is readily available (Wittig et al., 2006; Klimek et al., 2008).

Self-assessment as a means of facilitating PBR confers several advantages. Instead of relying on periodic expert assessment – which offers limited potential to inform in-year management decisions – self-assessment approaches have the potential to inform management decisions in 'real-time' by promoting ownership and understanding of outcomes. Self-assessment is also thought to reduce the expense of monitoring (Keenleyside et al., 2014), contribute to gaps in scientific knowledge (Loomis and Gascoigne, 2018), and increase farmer interaction and collaboration (Brown et al., 2010; Nye, 2018; Chaplin et al., 2019). Elsewhere in the literature, participation in self-assessment has had demonstrable impacts on farmers' knowledge of the impact of their management decisions (see Manning, 2017) and is thought to facilitate cultural acceptance and social value associated with agri-environment work (Burton and Schwarz, 2013; Birge et al., 2017; Saxby et al., 2018; Birge and Herzon, 2019). Despite these positive attributes, there are also risks associated with self-monitoring activities. There are numerous concerns relating to the additional administrative requirements for farmers (Nugent, 2013; Schroeder et al., 2013;

Russi et al., 2016). More fundamental concerns relate to farmers' skills and the challenge of verifying reported outcomes (Nugent, 2013; Birge et al., 2017), including, in particular, the difficulties associated with (self-) assessing mobile indicators (Zabel and Roe, 2009).

To this end, we now outline the pilot PBR scheme design and the methods utilised to explore the environmental performance of habitats under arable PBR agreements, assess the accuracy of farmer assessment of results, and farmers' attitudes towards the approach.

2.1. Pilot PBR scheme design

Government agency experts designed the pilot PBR scheme to test the delivery of 2 environmental objectives: provision of winter bird food for farmland birds and provision of pollen and nectar resources for pollinating insects. These were selected as examples of key priority biodiversity objectives in arable farming systems and ones where there is evidence of significant variability in their performance within conventional AES. For example, Hinsley et al. (2010) reported significant variability in seed yield between patches of winter bird food and Staley et al. (2018) found that only 20% of bird food plots surveyed in a conventional AES in England achieved their positive 'indicators of success' with nearly half of plots having less than 1% cover of sown species. Similarly, none of the pollen and nectar plots they surveyed met their positive indicators of success.

The reasons for this variation can be due to a wide range of factors, e. g., geographic location, seed choice, soil type, establishment techniques (especially for seed mixtures with different seed sizes), size of plots, seedbed conditions, sowing depth, sowing date, weather conditions, farmer commitment, and subsequent management. Most of these factors are within the control of the agreement holder and one way to improve the outcomes from the wild bird seed and nectar plots would be to increase the standard of management to match the level on commercial crops elsewhere on the farm (Stoate et al., 2004; Siriwardena and Anderson, 2006).

Links between winter seed provision and farmland bird populations have been established (Stoate et al., 2004; Siriwardena and Anderson, 2006). For example, at the farm level, Hinsley et al. (2010) reported that winter food provision increased the numbers of birds present at a farm and sub-farm scale in winter, with some evidence that this subsequently increased the breeding population. Declining floral resources in farmed landscapes are thought to be a significant cause for pollinator decline (Carvell et al., 2006), and growing numbers of studies have shown a positive correlation between the abundances of flowers and pollinators (Pywell et al., 2011; Dicks et al., 2015; Wood et al., 2015).

The experts selected results measures (see Table 1) and thresholds linked to tiered payment rates and an assessment methodology for each of the measures was developed. Extensive evidence about a positive relationship between the measure and the objective informed the selection of measures. Unlike grasslands, which have featured extensively in PBR and have well-developed approaches based on indicator species (e.g. see Kaiser et al., 2019), there are no similar arable examples to draw on. The result measures are proxy measures of intermediate outcomes rather than measures of bird or pollinator populations (which cannot easily be measured consistently at the farm or field level).

Table 1 Result indicators.

Objective	Result measure
Provision of winter bird food	Number of specified seed-bearing plant species present
Provision of pollen and nectar resources for pollinators	Number of specified flowering plant species present and in 2nd year after establishment % cover of specified species

The experts developed lists of specified species for each objective. These were based on good evidence of the benefits for the objective but were necessarily as long as possible to allow participants maximum flexibility in their choice of species/mix for specific sites (see Supplementary material for species list).

Options for the provision of winter bird food and of pollen and nectar resources are included as action-based management measures in two existing AES in England, Environmental Stewardship Scheme (ESS) (Natural England, 2013) and Countryside Stewardship Scheme (CSS) (Natural England, 2016). The winter bird food option requires the sowing of a balanced combination of small-seed bearing crops, such as fodder radish, quinoa, and white millet. The crop mixture has to be retained until at least 15 February before re-establishment in spring. The nectar flower mixture option requires sowing a mixture of nectar-rich plants (e.g., red clover, alsike clover, bird's-foot-trefoil, sainfoin, musk mallow, common knapweed), established in blocks or strips between 1 March and 15 September. Table 2 provides a comparison of the different scheme species requirements.

Table 2 Comparison of PBR and action-based scheme requirements.

	PBR	Environmental Stewardship (Action-based)	Countryside Stewardship (Action-based)
Winter bird food	Payment based on number of established species producing seed (from a list of 11 with five or more species achieving the maximum rate).	Minimum requirement to sow three small seed-bearing crop species from a list of nine.	Does not define a minimum number of species, but specifies that a mix of cereals, brassicas and other crops should be sown. Guidance on appropriate species.
Pollen and nectar	Payment based on number of flowering species (from a list of 20, with five or more species achieving the maximum rate).	Minimum requirement to sow four nectar rich species. Guidance on appropriate species.	A minimum of at least six nectar rich species sown, including at least two from a specified list of five.

2.1.1. Results tiers and payment rates

To establish payment rates, we calculated the income lost and net additional costs incurred as a result of adopting the farming practices necessary to support the biodiversity targets. This calculation establishes the net difference in income and costs between a conventional farming system for the relevant land type and the farming system necessary to deliver the maximum biodiversity results. Achieving the maximum results assumes that the participant incurs the full range of potential costs. The calculations also made an allowance for the participant's time to undertake the self-assessment of results and time to attend training events.

We used a payment structure with equally spaced payment rates, typically based on 6–10 tiers (including a zero payment). The top tier payment was based on the maximum rate calculated and the minimum rate was based on assumed minimum costs incurred to deliver the minimum acceptable level of performance and the intermediate rates as equal bands in-between. These payment tiers were mapped across to the result indicator scores (number of specified species present) to give scores related to each payment rate (Table 3), with five or more species achieving the maximum payment rate for both objectives. For the pollen and nectar objective, a second scoring criteria, percentage of cover, was also used in the second year after establishment. The presence of unspecified species, for example as a result of seed mix contamination, did not contribute to the scoring, and typically such species would contribute very little or nothing towards the specific objectives. The inclusion of a zero payment, making this a pure results-based approach, rather than a hybrid (with a guaranteed base payment and result-based 'top-up'), was a deliberate decision to test attitudes towards potential risk associated with non-delivery under a result-based approach. The payment structure aimed to achieve a balance between incentivising farmers to deliver the highest possible score (and therefore payment) and limiting the sensitivity of payments to the scoring system due to minor changes in result scores.

Table 3 Result thresholds and payment rates for first year PBR measures.

Results criteria: Winter bird food – Number of Established Sown Species Producing Seed Pollen and nectar – Number of specified flowering plant species present.	Winter bird food payment rate £ /ha	Pollen and nectar payment rate £ /ha
5+	£842	£705
4	£674	£635
3	£505	£564
2	£337	£494
1	£168	£423
0	£0	£0

3. Method

We adopted a mixed-method approach in this study. The method employed both an assessment of environmental outcomes using an experimental design with quantitative analysis and an analysis of farmers' attitudes using a qualitative survey.

The field study took place in the east of England in the counties of Norfolk and Suffolk, a predominantly arable area (see Map in Supplementary Material). Experts from the Government agency, Natural England, participated in the planning and implementation of the pilot.

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We applied some basic participant eligibility and selection criteria for recruitment. All participants had to be located within the pilot area and have existing action-based management under ESS or CSS, targeting equivalent outcomes. Those applying to deliver both outcomes and those with larger areas were prioritised within the available budget. A list of over 250 eligible farms was produced and a flier was posted to each one inviting them to express an interest in participating in the pilot. Thirty-six farmers responded and registered an interest and the top 15 farmers ranked by the selection criteria were invited to participate.

We provided the participants with extensive advice on how to achieve the best environmental outcomes. This was achieved through a range of guidance materials, 1:1 farm visits, farm walks and training events. They received training on the assessment methodologies and undertook trial assessments, with expert feedback, during 2016. The guidance documents included both detailed descriptions of the scoring methodology and scorecards (see Supplementary Material) and extensive good practice guidance on potential management interventions to support the delivery of the biodiversity targets.

3.1. Plot selection

In addition to the PBR plots we identified a set of control sites (under the CSS action-based scheme management) within the pilot area (referred to in the analysis as control). These were matched in clusters with participant sites, according to key characteristics, such as age from establishment. All the participants also had equivalent existing ESS action-based management plots on their holdings (referred to as baseline), providing an opportunity for further comparison. The timing of the pilot coincided with the switch from the ESS to the CSS in England and necessitated using the CSS to provide wider control plots. Table 4 details the numbers of the PBR, control and baseline plots. We assessed the control and baseline plots using the PBR methodology at the same time as the PBR plot assessments. Non-parametric statistical comparisons between the results for these three groups was undertaken.

Table 4 Baseline and control comparison plots.

	Year	Number of plots		
		PBR	Baseline	Control
Winter bird food	Year 1	18	15	13
	Year 2	18	14	13
Pollen and nectar resources	Year 1	11	11	13
	Year 2	11	9	13

3.1.1. Vegetation surveys

The experts defined assessment protocols specifying the methodology, scoring, and assessment timing for each of the objectives. The assessment comprised of 3 basic steps:

1. Complete 10 x 1 m^2 representative quadrats per plot.
2. Record the number of plants/seed heads per quadrat for each specified species present (see Supplementary Material). Additionally, for the winter bird food objective species-specific thresholds were established for the minimum number of plants/seed heads required within a quadrat to ‘score’ (e.g., cereals 25 seed heads, Quinoa 2 plants).
3. Total number of species calculated as those present in 5 or more quadrats.

The Government agency arable habitat experts developed and tested the thresholds and assessment methodologies using existing reference sites in the pilot areas considered to represent the full range of outcomes for the objectives. This allowed the maximum and minimum levels to be calibrated and the assessment methodologies to be tested and refined.

3.2. Assessment of accuracy of farmer self-assessment

A key design principle of the pilot was to develop result measures that could be self-assessed by participants. In addition, experts assessed all pilot sites to enable an analysis of the accuracy of the farmers' self-assessments. A small proportion of expert assessments were also subject to independent review to test the consistency of the methodology.

3.3. Farm characteristics and attitudinal survey

The researchers conducted two participant surveys comprising a mix of closed and open questions (see questionnaire in Supplementary Material). The first was completed in early summer 2017 (year 1) before participants had completed their first-year assessments. The second survey was conducted in late 2018 (year 2) after the farmers had completed their second year's assessment. The timings were intended to capture some 'before' and 'after' views and how these may have changed. The questions aimed to understand the background of the participants and farm structural characteristics, their reasons for being interested in the pilot, their views of a PBR approach and specific questions on the habitats they were managing in the pilot. In the second year, the researchers repeated a number of questions to see if views had changed and they added some additional questions focused on the role of advice and support.

4. Results

4.1. Farm and farmer characteristics

Fifteen farmers participated in the experiment, enroling a total of 42 ha of land in 2-year agreements (2016/17 and 2017/18) (Table 5).

Table 5 Summary of pilot agreements.

	Winter Bird Food	Pollen and Nectar	TOTAL
Number of pilot agreements	15	11	15 (most delivering both objectives)
Total area under agreement (ha)	25.04	16.94	41.98

The characteristics of the participants and their businesses are broadly representative of arable farms in England. All participants are male, with the majority falling into the 45–64 age brackets. The average size of the participating farms is 288 ha, ranging from 77 to 703 ha, the majority considered farming their primary business and most have been in farming for more than 20 years, with a small number of more recent entrants (see Supplementary Material for participant details).

4.2. Environmental performance

4.2.1. Winter bird food

The PBR plots consistently contained more established seed crops than both the baseline and control plots. Fig. 1 illustrates that the PBR plots had an average of 4.9 crops compared to 2.9 for the baseline and 2.7 for the controls, although the average was slightly higher in year 1 for the PBR plots (5.3) compared to year 2 (4.5) a pattern which was replicated in the baseline plots (2.9 and 2.6 respectively). Conversely, the average for the control increased between these years from 2.5 to 3.0.

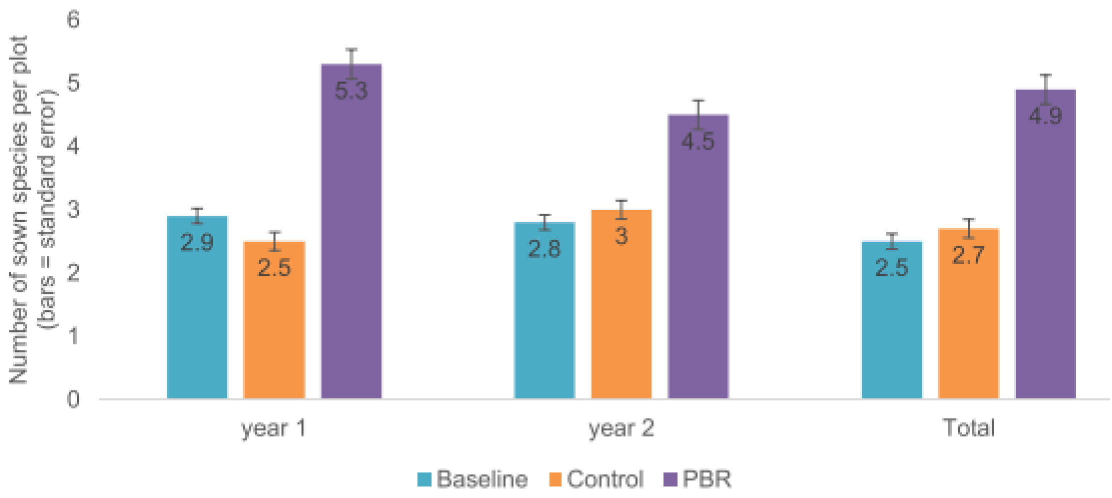

Figure 1 Winter bird food: average number of seed-bearing sown species.

For the baseline plots, 48% had a lower number of crops (two or fewer) than the prescriptions required and some plots had no crops recorded at all; 13% in year 1 and 14% in year 2. For the control plots, the results were similar, with 50% of the control plots surveyed (13) having two or less seed species present and 8% (2) no established crops. In comparison, none of the PBR plots had fewer than two crops. Comparing the total values of these three groups (by pairwise Wilcoxon Test with corrections for multiple testing), those for PBR are significantly higher than both baseline ($P = 0.002$) and control ($P < 0.001$).

For the management of the PBR winter bird food plots, in year 2, 75% of the farmers revealed in the survey that they managed their plots differently from their equivalent mainstream agri-environment plots with a range of different activities. This included taking care over the timing of drilling due to the dry conditions, additional seed added, different seed mixes used, fertiliser and plant protection products applied, and the ability to make better use of equipment (as the plots were bigger than conventional AES). One farmer even tried irrigation, although this did not affect the results.

4.2.2. Pollen and nectar

As Fig. 2 illustrates, the PBR plots had an average of 6.3 species compared to 3.8 for the baseline and 5.2 for the control plots. Comparing the total values of these three groups (by pairwise Wilcoxon Test with corrections for multiple testing), those for PBR are significantly higher than baseline ($P = 0.002$) (and other comparisons are not significantly different). Eighty-three percent of the PBR plots had five or more species resulting in the top payment rate with an equal percentage of plots in each year achieving this outcome. This compared to an overall total of 45% of the baseline and 48% for the control. None of the baseline plots had more than seven species, whereas some of the control and the PBR had up to 10.

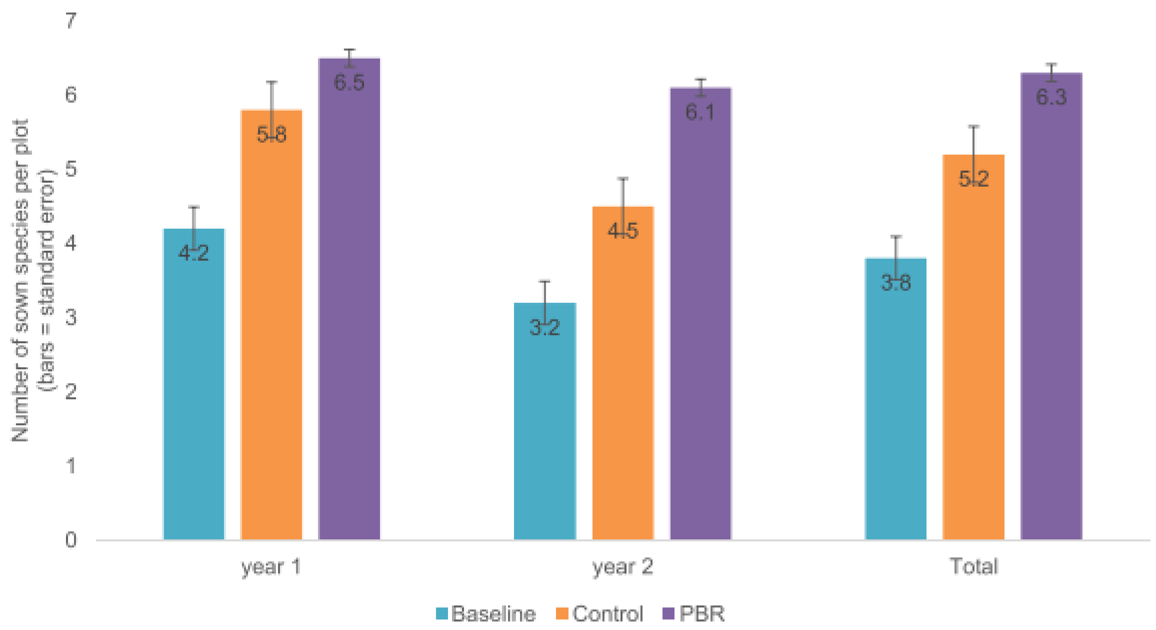

Figure 2 Pollen and nectar: average number of sown species present.

With the PBR pollen and nectar plots, most of the farmers used existing standard mixes with some modifications. There were relatively small differences between seed mixes and seed rates reported, for example in pollen and nectar plots the average number of sown species varied from 11.4 (PBR), 10.5 (Baseline) and 9.4 (Control), and average seed rates 18.76 kg/ha (PBR) compared to 17.23 kg/ha (Baseline) and 17.38 kg/ha (Control). Other changes in management practices included applying a flexible and better-timed topping regime and cutting and removing arisings, and spot treating weeds.

4.3. Participant views

The participants offered a range of views and suggestions about the design of the pilot, the selection of result measures (and alternatives), the number of payment tiers, and the use of a zero-payment threshold. The majority of participants were positive about the detail of the pilot design in the initial survey, but their views had changed somewhat by the second survey.

At the outset, all the farmers felt the results measures employed for the pollen and nectar options were the right ones for this option and that the survey methodology was the best way of measuring these results. However, at the end of the project, 33% of farmers felt that the assessment criteria or methodology should be changed. Suggestions on what could be done differently mainly centred around adopting a set sampling pattern for plots.

When asked about the use of a zero-payment if none of the results are achieved, the majority of participants (60% in the first year and 75% in the second year) were against the idea. Despite successful delivery under the arable measures in year 2, even under very challenging weather conditions, there was a strengthening of feeling rising to 75% who felt that a zero-payment rate was not appropriate. The participants considered the risks associated with failing to deliver these annual management options high, as the following quote illustrates:

> "The inherent risk of the planted areas failing en masse without the guarantee of my costs being covered would prevent me from switching all my areas to RBAPS [Results based agri-environment payment scheme], however, if this was to be agreed it would be a more attractive way to take payments forward" (Farmer 8, 200ha+, owned, age 45–54)

although the same farmer also observed:

> "risk provides focus".

Participants expressed reasonable levels of confidence about their ability to decide the appropriate management required to achieve the best results for the two options (Table 6). Farmers were generally 'quite confident' in applying the management practices required for winter bird food, although slightly less confident about the management practices needed for the pollen and nectar mix.

Table 6 Participants' level of confidence in ability to select appropriate management practices.

No. of farmers	Not at all	Quite confident	Very confident
Winter bird food	0	11	3
Pollen and nectar mix	3	7	3

The participant's level of confidence in their ability to undertake the self-assessment was lower than their confidence in their management abilities (see Fig. 3), with a significant proportion of the participants responding 'not at all confident' at the start of the project. By the time of the second survey, confidence levels had increased for both options, with only one participant expressing a lack of confidence.

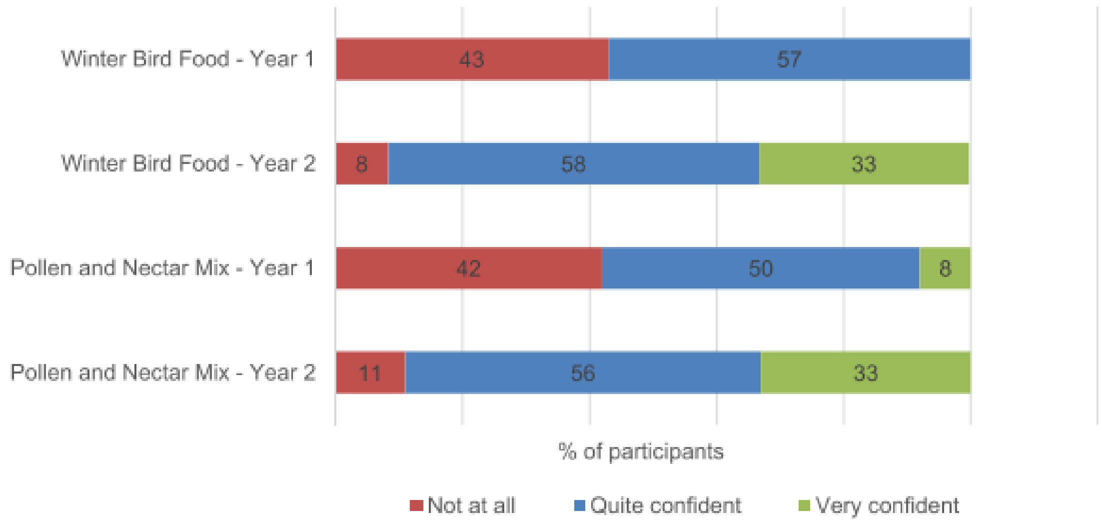

Figure 3 Participant's level of confidence in ability to undertake the self-assessment.

The participants' views on the key advantages and disadvantages of the PBR approach were captured through open questions in the survey and can be summarised as:

Advantage (no. of responses)	Disadvantages (no. of respondents)
Reward for effort (8)	Crop failure and risk of no payment (14)
Flexibility and freedom (7)	Time-consuming to complete assessments (5)
Ability to use local knowledge (3)	Time consuming to manage properly (2)
Improved management and wildlife knowledge (3)	Weed problems (2)
Incentive to produce better results (2)	More time-consuming for the administrators due to increase in checking (1)

Three key themes emerged from the open questions in the survey: fairness and equity; freedom and flexibility; and concerns around establishment failures.

4.3.1. Fairness and equity

A key positive theme that emerged from the responses was one of fairness and equity. The participants felt the approach fairly awarded those who applied the most effort, as the following quotes illustrate.

> “It directly rewards for skill, effort and care” (Farmer 3, 100 – < 200 ha, owned, age 55–64)

> “The more that you put in, the more that you get out” (Farmer 4, 100 - < 200 ha, owned, age 25–34)

4.3.2. Freedom and flexibility

The respondents also valued the freedom and flexibility to decide on the most appropriate management to achieve the required results based on their knowledge of their land, as the following quotes highlight:

> “It puts the farmer firmly in the driving seat making the decisions and rewarding his skill and experience.” (Farmer 3, 100 - < 200 ha, owned, age 55–64)

“It gives more freedom to us to achieve the results and is an incentive to treat stewardship areas with as much attention as arable crops.” (Farmer 4, 100 - < 200 ha, owned, age 25–34)

“Being left to grow without being told how to.” (Farmer 2, 50- < 100 ha, owned, age 45–54)

4.3.3. Establishment failure and non-payment risk

Views about the main disadvantages of the scheme clearly related to concerns over establishment failure due to factors outside of their control, such as weather or pest-related issues and therefore the risk of non-payments.

“Establishment failure due to weather or pest problems, I think there needs to be a minimum payment to cover the farmers cost.” (Farmer 4, 100 - < 200 ha, owned, age 25–34)

“That the crops don’t establish on our heavy clay soil or get swamped with weeds.” (Farmer 6, 200 ha +, owned, age 35–44)

The majority of the participants attended the training events offered. The feedback from these events was positive, particularly as they provided a valuable opportunity for participants to meet and share their experiences. The participants considered this ’peer-to-peer’ learning as a valuable aspect of the results-based approach, as the farmers could share knowledge of how to achieve the best scores. They felt that this type of interaction is of limited value in a prescriptive approach because of the inherent inflexibility in choice and timing of management interventions. They also highly valued the 1:1 advice, especially supporting the baseline result assessment process and the provision of bespoke management advice based on these assessments. This finding is reflected in the higher proportion of participants who identified that they were quite or very confident about undertaking the self-assessments at the end of the project.

4.4. Accuracy of self-assessment

4.4.1. Winter bird food

There was a slight reduction between year 1 and year 2 in the proportion of assessments where the self and expert assessments matched. Overall, in 36% (13) of cases, the different assessments found the same number of crops (see Fig. 4). In year 1, 44% (8) of the self-assessments found one more crop than the expert, and 17% (3) found one less. In year 2, there was more variability, with the expert finding two more crops than the self-assessment in 11% (2) of plots and the farmer finding four more crops in 6% (1). When we translated this to payment tiers (Fig. 5) 67% of plot assessments resulted in the same payment tier. In year 1, 78% (28) of the assessments agreed on the payment tier, with a smaller percentage (23%) having a difference of 1 tier. There was a greater disparity in year 2, with only 56% (10) agreeing, and 17% (3) of plots measured by self-assessment were 2 payment tiers higher than the expert.

4.4.2. Pollen and nectar

Fig. 6 shows that, overall, 36% (8) of self and adviser assessments found the same number of species. However, there was a marked change between year 1 and year 2 with a decline from 45% (5) to 27% (3). In year 1, 9% (1) of the self-assessments found one more crop than the adviser, 27% two more and 9% three more, while 9% found one less. However, in year 2 this became more dispersed, with 27% finding one more species, 9% three more, 9% one less and 14% two less. When this is translated to payments, the difference is not as severe, as plots with five species or more all receive the top payment tier.

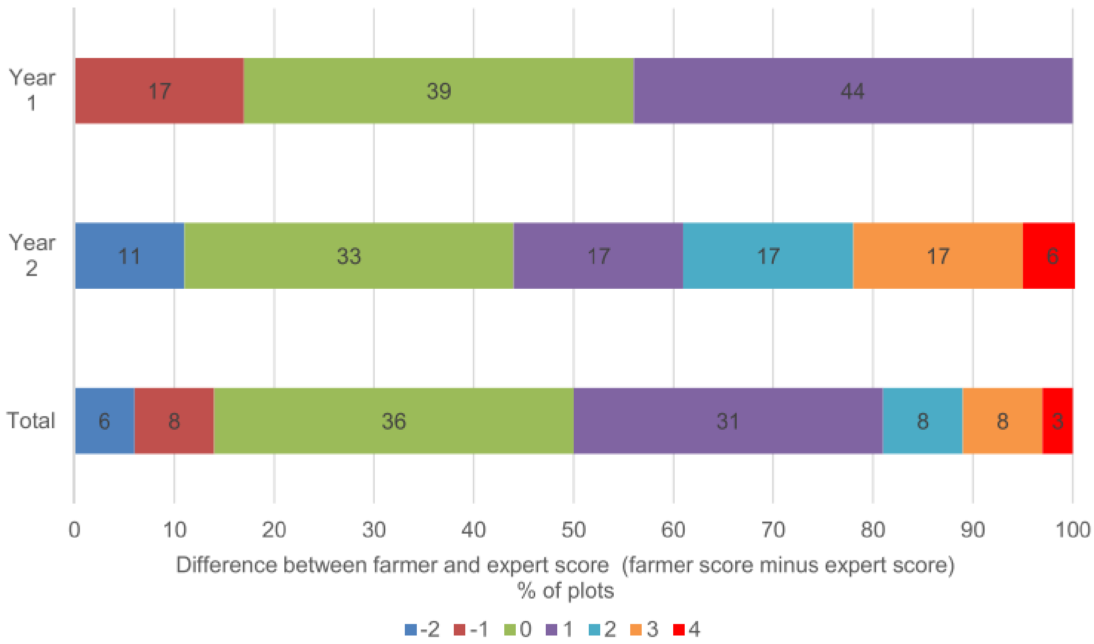

Figure 4 Winter bird food: accuracy of farmer assessment, difference in number of sown species recorded.

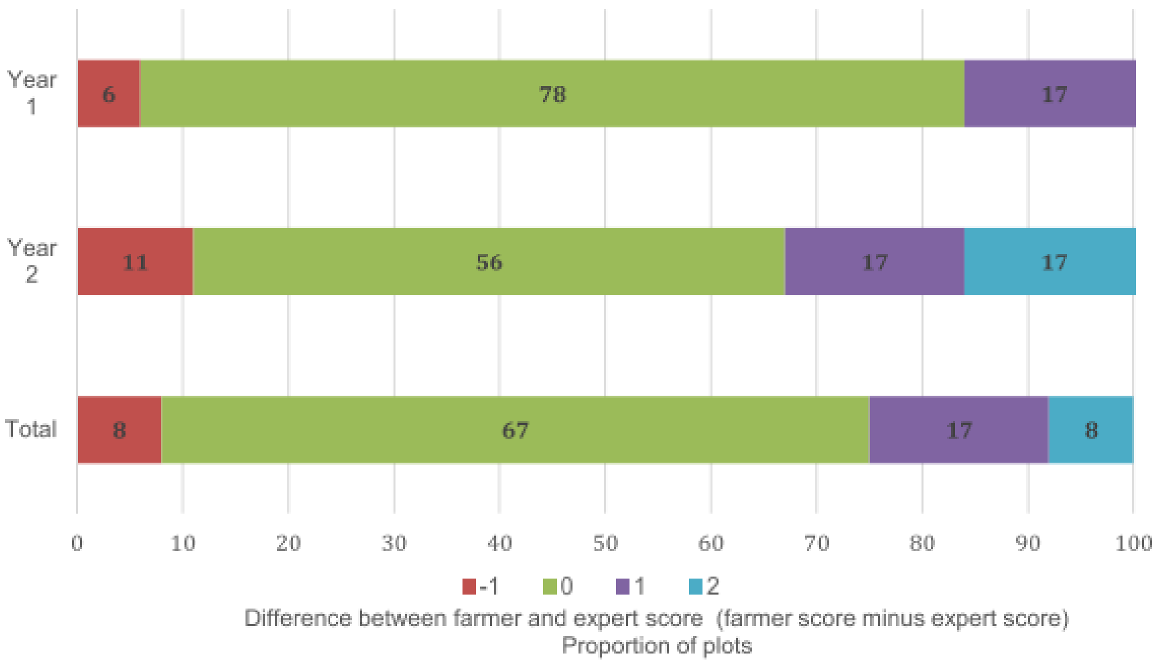

Figure 5 Winter bird food: accuracy of farmer assessment, difference in payment tier.

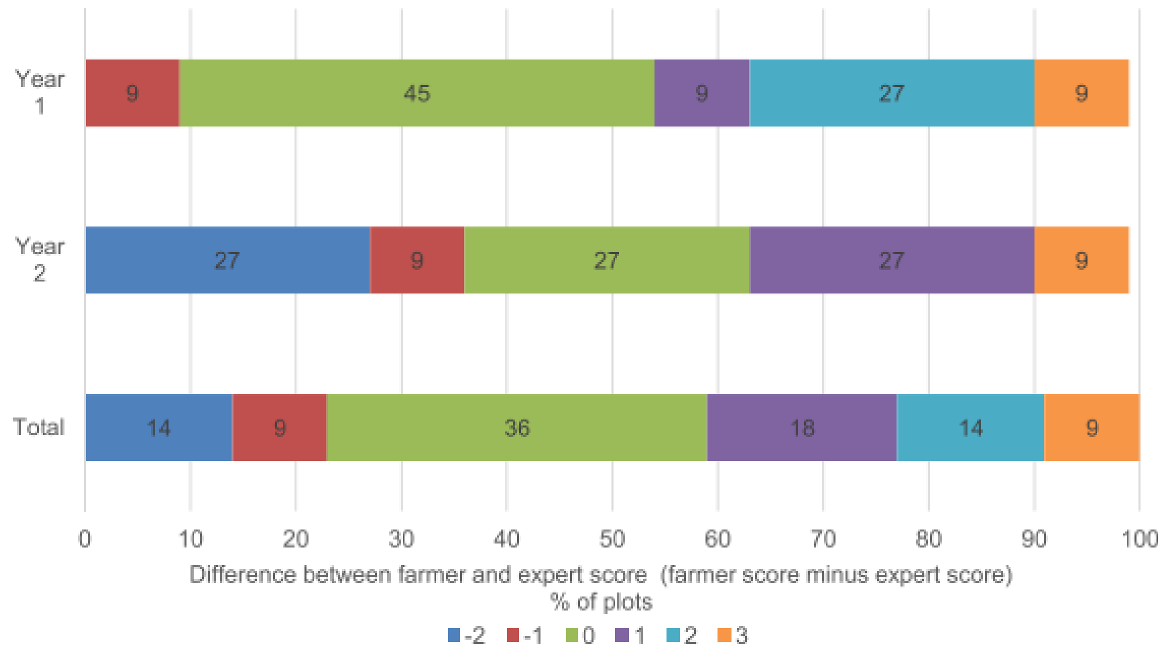

Figure 6 Pollen and nectar: accuracy of farmer assessment, difference in number of sown species recorded.

Fig. 7 illustrates that in year 1, 82% (9) of the self-assessments resulted in the same payment tier as the adviser, with the remainder one tier higher than the self-assessment. There was a bigger difference in year 2, with only 55% (6), agreeing although the remainder were all no more than 1 payment tier different. For the percentage cover measure assessed in year 2, 64% of the adviser and self-assessments fell within the same tier, while the self-assessment was one tier higher for the remainder.

5. Discussion

The aim of this paper was to identify the potential effectiveness of a PBR approach for arable farming systems. The paper also sought to assess the accuracy of farmer self-assessment of results and explore land managers' attitudes to PBR. Whilst we acknowledged that the small number of participants in the study limits the potential to draw broad conclusions, we believe the findings do offer insights into a novel PBR approach that can be explored in more depth in future research.

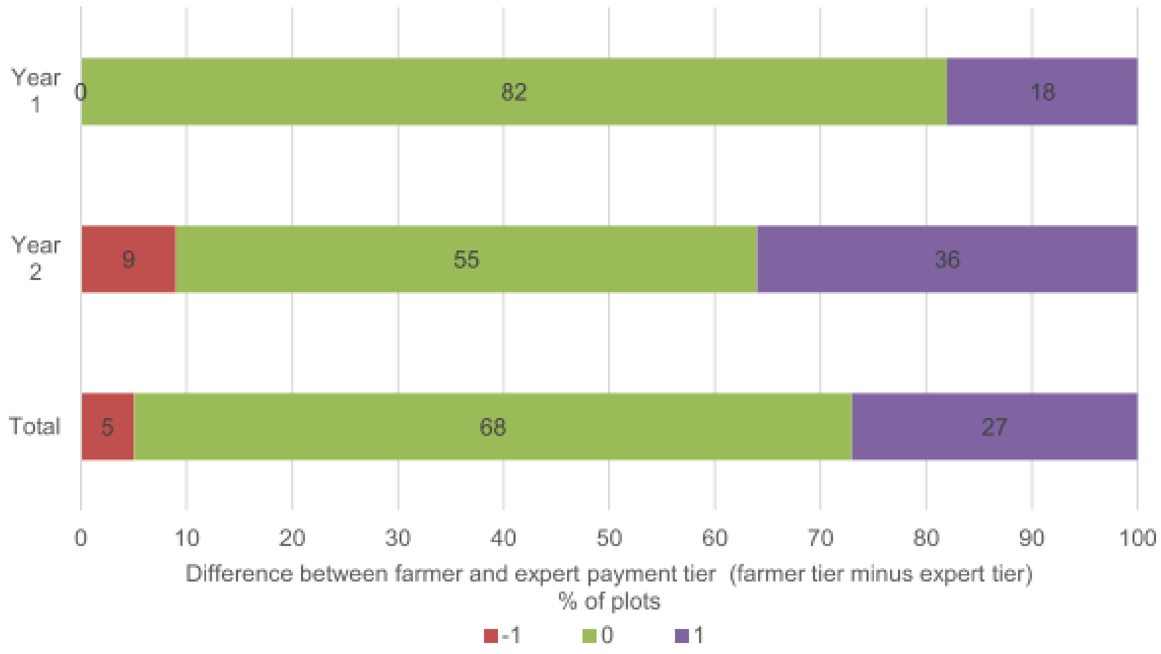

Figure 7 Pollen and nectar: accuracy of farmer assessment, difference in payment tier

5.1. Result indicators and self-assessment

The results have revealed an improved environmental performance of the PBR winter bird food plots and pollen and nectar plots compared to similar measures implemented under conventional AES. However, one potential limitation of the research findings for winter bird food is that the lower average number of seed-bearing sown species identified for the baseline and control plots could be attributed to the lower number of seed crops required in the prescription for these mainstream AES. Even so, nearly half of the baseline and control plots had a lower number of crops (two or fewer) than the prescriptions required or no crops at all. Similarly, for the pollen and nectar plots, the differences compared to the baseline plot could be attributed to the lower number of species required, although 40% of these plots actually had a lower number of species than the management prescriptions required (four). For the control plots, which required six species, the results showed that 67% had fewer than required.

As already noted, successful establishment of these crops is dependent on a complex mix of management decisions, including seed mix, seed rates, seed bed quality, drilling depth, drilling timing, applications of fertiliser and plant protection products to support initial establishment and decisions on re-sowing in response to poor establishment or deterioration over time (pollen and nectar). Slightly higher seed rates, seed mixes with greater numbers of species, increased rates of fertiliser application and herbicide use during establishment were all reported for PBR plots compared to baseline and control plots. The role of factors such as the quality of the seed bed and timing of operations, e.g., in the context of seasonal weather conditions, is much harder to quantify. Regardless of the slightly different requirements of the PBR, baseline and control plots, the improved performance of the PBR plots appears to reflect a greater attention to detail across a range of these management decisions.

The results have also identified a high correlation of farmer self-assessment of results with expert assessments, despite some participant’s initial lack of confidence in their ability to undertake self-assessments. These results indicate a clear potential for the delivery of such an arable-based PBR with a self-assessment element. However, we have also identified challenges where further research is required.

The literature has repeatedly identified the challenge of finding suitable result indicators as a barrier to the more widespread adoption of results-based approaches (Burton and Schwarz, 2013; Birge et al., 2017; Herzon et al., 2018). Extending the approach to environmental resource provision in arable farming systems has necessitated the development and use of bespoke proxy indicators of intermediate results (seed provision and floral resources) rather than final objectives (bird and pollinator populations). This does necessitate on-going assessment to confirm that intermediate measures are good proxies for their objectives and that there is no divergence over time.

A particular challenge in developing simplified indicators suitable for self-assessment is the risk that the indicator drives delivery in an unforeseen way that is inconsistent with the overall objective or what Zabel and Roe (2009) term as ‘distorted measures.’ This unforeseen effect has been observed to some extent with the winter bird food plots, where the focus of the indicator on seed production has resulted in plots with less desirable structural characteristics and highlights the need for field testing of such measures.

In selecting indicators, attention should also be paid to any potential risk of perverse outcomes. The pilot farmers clearly made different management decisions for their PBR plots compared to their conventional AES plots, carefully considering how to produce results and secure a higher payment rate. However, the survey revealed that some farmers took a more productivist view towards managing their PBR plots in the same way they might manage a commercial crop, applying more fertiliser and permitted plant protection products during the establishment phase than they would have done under an action-based contract, potentially increasing environmental risks.

One challenge of the PBR approach identified by the farmers in the survey is the time requirements for self-assessment, although this was not quantified. In fact, it is possible that the time associated with undertaking self-assessment of results by participants on a larger number of plots/fields, across a wider range of environmental objectives, at a whole farm scale, could be considerable and requires further research. The scheme payments include an element for the time required to undertake the assessments so the time itself need not be a barrier. However, if the timing of assessments for different outcomes coincided with peaks of agricultural activities, this could be a particular challenge. The time spent by participants on self-assessment would likely reduce as they develop the skills and confidence to undertake the assessments, and there is some evidence from the pilot of this happening. However, this issue clearly needs further consideration in the context of an overall scheme design. For example, it might be possible to reduce the frequency of some assessments or reduce the number of stops per plot, subject to further testing of the repeatability of different survey methodologies.

There are also opportunities to explore the use of technology to support the process of self-assessment undertaken by farmers/land managers. In particular, to support more accurate assessments of results by land managers at the field/farm-level, such as species identification or assessments of habitat structural variables, such as percentage cover. In this context, there must be scope for real-time or rapid feedback from such tools to inform management decisions.

Another disadvantage of the PBR approach highlighted in the results is the resource required to verify results. The pilot has necessarily employed 100% independent assessment of results annually. Translating such an approach into a mainstream scheme is unlikely to be feasible because of the volume of assessments required. However, the pilot has demonstrated a high level of accuracy of self-assessment results for the two measures, which indicates that such a level of verification is probably not necessary, and a risk-based approach focused on independently sampling a small proportion of sites each year could be adopted. Selection could be informed by factors such as significant changes in self-assessed scores or evidence from remote-sensed data suggesting a discrepancy between a self-assessed score and actual condition on the ground.

5.2. PBR and risk preferences

A particular attraction of fixed-price payments under conventional multi-year AES is that they provide a guaranteed source of income (Vollenweider et al., 2011; Mills, 2012). Conversely, the meta-analysis by Lastra-Bravo et al. (2015) suggested that when farm income is a high proportion of household income, participation in AES was less likely, as joining was seen to risk reducing overall income. While fixed-price schemes may play a role in financial risk management, a pure results-based approach foregoes this potential benefit. This outcome is especially true in an arable context, where, for example, winter bird food is grown as an annual crop, so the risk of non-delivery, and therefore no income, is present every year. The survey participants expressed concern about the risk of non-payment due to establishment failure. It could be argued that the risk involved is little different to mainstream agricultural production, although as farmers may have less experience of these non-agricultural crops, they are likely to be more risk averse in this context. Perceptions of risk have been identified as a potential barrier to PBR uptake (Schroeder et al., 2013), but whilst the role of risk preferences in agricultural production decisions is subject to an extensive literature (e.g. Gardebroek, 2006; Iyer et al., 2020), there has been little consideration of risk in the production of environmental public goods, which is likely to be a significant consideration and requires further research.

The survey elicited strong attitudes towards environmental delivery risk and tended to confirm that this risk would represent a barrier to the wider adoption of the approach. Weather is the most significant risk that affects both agricultural and environmental results and the drought conditions experienced in the East of England during the spring of 2018 provided a valuable test. However, despite this exposure to extreme risk, the majority of plots performed extremely well and continued to significantly outperform control plots in conventional action-based agreements, which suggests this weather-related risk is manageable.

Successful delivery of many biodiversity outcomes is closely linked to factors affected by the weather, such as crop establishment. Result indicators that are very sensitive to weather conditions should only be used where potential management interventions are available to directly influence these characteristics. Provided that this is the case, it is not unreasonable to expect farmers to make more interventions in some years to deliver optimum results (or accept a lower level of results, which is no different to agricultural production affected by weather). However, the pilot has highlighted a need for clear safeguards to apply if land managers experience truly ’exceptional weather’, so that they are not unfairly exposed to risk beyond their control and are aware of this when they enter an agreement. This issue has been raised in previous PBR studies (Nugent, 2013; Russi et al., 2016), although these have almost exclusively been implemented in existing grassland habitats where the risk of sudden changes in results and the influence of the weather are less pronounced. The pilot has explored a number of potential options for dealing with extreme weather, and different approaches may be more suitable for different outcomes.

One approach used widely to manage risk is hybrid schemes with a guaranteed payment linked to implementing specific actions alongside a results-based bonus/top-up, and the majority of existing schemes operate this approach (Herzon et al., 2018). However, there is a danger that such an approach undermines the inherent motivational/behaviour change strengths of the result-based approach. It is possible that combining action and result-based elements may also entail greater administrative effort for farmers and scheme administrators, checking that both actions have been delivered and assessing/verifying results. The number and value of the steps in a tiered system are important considerations as they are key drivers for encouraging farmers to produce better results and increase their payment. The project used evenly spaced payment tiers, primarily for simplicity and lack of strong evidence for an alternative approach. An alternative is to vary the number of payment tiers and use a non-linear spacing of tiers to balance risk and reward. These issues require further research.

A greater understanding of how farmer confidence and expectations develop over time as they engage with the PBR approach is needed. Especially whether their initial motivation wanes as participants develop experience of the approach (and are successful or otherwise), especially for those environmental objectives, such as habitat condition, that are typically very slow to respond to changes in management. Also, whether the PBR approach will encourage land managers to take proactive management actions to maintain a certain quality/payment level. This is particularly pertinent for the pollen and nectar resource provision, a multi-annual sown mix prone to quality deterioration over time.

5.3. Training and advice

The findings also highlight the need for extensive training and advice, especially in the early stages of implementation, to support management and the self-assessment process. The PBR approach represents a considerable culture change for farmers, changing the scheme risk from non-compliance with prescriptions to non-delivery of results. Experience from the pilot shows the potential need for high levels of support in the early stages of adopting the results-based approach as farmers develop the necessary skills and confidence. Given that the farmers value the PBR approach for its fairness by rewarding those who apply the most effort, there should also be equitable access to this support. This requirement would be especially true across a scheme with a wider range of result-based objectives. It is likely that this advice and support would predominantly be a temporary requirement in the initial stages of implementation as indications from the pilot suggest that farmers can develop the necessary skills and grow in confidence quickly.

6. Conclusions

This paper has sought to identify, for the first time, the effectiveness of a PBR approach for arable farming systems rather than for grassland systems. The paper is particularly timely as policy-makers at both the UK and EU levels are currently exploring the potential of the PBR approach to support the long-term sustainability of the environment.

The PBR approach required for an arable system differs from a grassland system because crops are re-sown each year rather than grown continuously, which increases the risk of non-delivery. Despite these risks, the results from the pilot PBR scheme presented in this paper have revealed that there is clear potential for the delivery of such an arable-based PBR, although further research is required.

The environmental performance of the two management options tested under the arable PBR agreements clearly performed better than the same options under conventional action-based approaches. Furthermore, early indications suggest that scheme payments are unlikely to significantly differ with those of management-based measures, suggesting that the approach could deliver some efficiency gains. It is also clear that the approach could be applied to a wide range of biodiversity objectives and many other environmental objectives associated with land management practices.

The use of farmer self-assessment of the results can achieve greater farmer engagement from increased ownership and understanding of the outcomes. Despite some initial lack of confidence in their ability to self-assess, the accuracy of the farmer assessments was similar to those of the experts, although extensive advice and training are required to support the process. Further research is required to identify the time requirements for self-assessment of results at a whole farm scale.

A pure results-based approach was adopted for this pilot as it provides an important motivation and a value-for-money safeguard to ensure payments are only made for performance above a defined minimum level. However, farmers were concerned about the potential risk of poor results, and therefore non-payments, due to factors beyond their control. This risk is exacerbated with arable options that are managed on an annual basis.

Clearly, further work is required before the PBR approach can be fully mainstreamed in arable systems, however, experience from the pilot is very positive and suggests that the approach has considerable potential to improve the delivery of environmental outcomes in the future.

CRediT authorship contribution statement

S.P. Chaplin: Conceptualization, Methodology, Formal analysis, Writing – original draft, Investigation, Resources, Data curation, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. J. Mills: Formal analysis, Writing – original draft, Writing – review & editing, Visualization. H. Chiswell: Writing – original draft, Writing – review & editing.

Acknowledgements

We would like to acknowledge the support of the European Commission for funding the pilot project under EU grant agreement No.07.027722/2015/721692/SUB/B2 - Pilot Results-Based Payment approaches for agri-environment schemes in arable and upland grassland systems in England. Also special thanks to the Natural England staff working on the project, Annabelle LePage, Vicky Robinson, David Ward, David Whiting, Clare Bains, Damian Hicks, Eva Scholz, Patrick Woods, Lucy Hatcher and to all the farmers participating in the pilot scheme. We would also like to thank the two anonymous reviewers for their constructive comments on the paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105698.

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