Farmers' Expectations of Climate Action: Evidence from an Information Experiment

Felipe Aguiar*, Doris Läpple, Cathal Buckley

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Abstract

A key measure to reduce chemical fertilizer application, and thereby mitigate greenhouse gas (GHG) emissions from agriculture, is the introduction of clover into grazing grass. However, adoption of this measure remains low. In this context, information and expectations can influence adoption decisions around clover. So far, there is little evidence of how farmers update their expectations in response to information. In this study, we used an information experiment to assess how providing information affects farmers' expectations about clover, and how this in turn influences subsequent attitudes. We collected data from over 300 dairy farmers in Ireland, which were randomly assigned into two information treatment groups and one active control group. While both treatments provided information about the reduction in chemical fertilizer associated with adoption, each treatment framed the information differently. To elicit farmers' expectations, we combined qualitative open-ended questions and quantitative point estimates. As for the subsequent attitudes, we elicited farmers' intentions and willingness to accept (WTA) clover adoption. We estimated treatment effects by employing a two-stage least squares regression. To examine responses from the open-ended questions, we used three text analysis methods: wordclouds, keyness, and topic analyses. We document that farmers have biased expectations about clover adoption. They underestimate the reduction of chemical fertilizer that is possible with adoption, and we provide causal evidence that information reduces misperceptions by up to 19%. Yet, through the text analysis, we discover that information increases the likelihood of having not only a positive change, but also a negative change in opinions around clover adoption. Lastly, there was no meaningful impact of the updated expectations on intentions and WTA, which underlines the complexity of adoption decisions. Nonetheless, our findings are relevant to help construct accurate expectations that can facilitate more widespread adoption of clover.

Keywords: behavioural economics, climate change mitigation, expectations, information experiment.
JEL Codes: C90, C93, D83, D91, Q12, Q16, Q56

*Corresponding author: f.aguiarnoury1@universityofgalway.ie

1 Introduction

Nitrogen (N) is an essential element for life. Apart from its biological role in the human body, nitrogen is fundamental to produce food. It is a key nutrient needed in farming to fertilize land, and ensure growth of plants, grass, and crops. The application of nitrogen in the form of chemical fertilizer is the conventional approach to boost plant growth, especially in North America, Europe, East Asia, and South Asia. However, chemical N fertilizer use at the farm level is the main driver of nitrous oxide (N_20) emissions in these regions (Tian et al., 2020). N_20 is a strong greenhouse gas (GHG) with a long atmospheric life. It has 265 times the global warming potential of carbon dioxide, and its molecules can live in the atmosphere for over 120 years (Intergovernmental Panel on Climate Change [IPCC], 2013). Nowadays, the world's agricultural activity accounts for around three-quarters of global N_20 emissions (Mbow et al., 2020), and agrifood systems are responsible for more than one-third of global GHG emissions (Crippa et al., 2021).

In Ireland, agriculture is responsible for 92.6% of national N_20 emissions (Environmental Protection Agency [EPA], 2022a), and for 38.4% of GHG emissions, being the sector with the largest share of national GHG emissions (EPA, 2022b). Specifically, chemical N fertilizers are responsible for 40% of national N_20 emissions (Department of Agriculture, Food and the Marine [DAFM], 2020). In line with the European Green Deal, the Irish government has set legally binding targets to reduce GHG emissions and achieve a climate-neutral economy by 2050 (European Commission [EC], 2020). This involves a reduction, relative to 2018 emissions, of 51% of national GHG emissions by 2030. In particular, the Irish agricultural sector needs to reduce 25% of GHG emissions by 2030, compared to 2018 levels. To achieve these targets, the government has set as the main strategy the implementation of new farm practices that mitigate GHG emissions from agriculture and produce high quality food (Department of the Environment Climate and Communications [DECC], 2022).

One key farm practice, to reduce the application of chemical N fertilizer and mitigate GHG emissions is the incorporation of clover into grazing swards (Lanigan et al., 2018; Buckley et al., 2020; Climate Change Advisory Council [CCAC], 2021). This practice allows for natural N fixation from the atmosphere, and its benefits are well established in the literature (e.g., Caradus et al., 1995; Humphreys et al., 2012; Burchill et al., 2014; Egan et al., 2018). Unfortunately, uptake of clover and other GHG mitigation measures has remained low (EPA, 2022c). Clover adoption is favorable in extensive pasture-based farming systems, such as those in Australia, Ireland, New Zealand, and Wisconsin (USA). Besides Ireland, there is also a considerable potential for adoption in other Western European countries (e.g., France, Germany, Netherlands) due to environmental regulations, and rising fertilizer costs (Humphreys et al., 2017). In this paper, we focus on the role of information provision in assessing farmers' expectations about this important farm practice.

The process of adoption decisions starts when the farmer receives information about a new farm practice. Then, available information about an innovation impacts the expectations of the farmer, which in turn influence their subsequent attitudes and behaviour of adoption or non-adoption[1] (Schultz, 1975; Feder et al., 1985; Chavas & Nauges, 2020). Therefore, information interventions are important as they can help build positive expectations about the benefits from clover, and generate adoption decisions. However, information provision in agriculture is a complex process with a mixed record of success (Aker, 2011; Läpple & Hennessy, 2015; Tjernström et al., 2021).

While there have been previous information provision experiments in different agricultural contexts (e.g., Hanna et al., 2014; Peth et al., 2018; Buchholz and Musshoff, 2021), only a few have studied how farmers incorporate information of an innovation and revise their expectations about it (e.g., Tjernström et al., 2021; Gars et al., 2022). In addition, past studies have found that farmers' adoption decisions can be influenced by experiences and opinions of their peers (e.g., Barham et al., 2018; Läpple and Barham, 2019). This might be true in relation to the adoption of clover. Thus, farmers receiving information framed as behaviour of their peers might react differently than if they were receiving information framed as scientific research. However, little is known about how framings of similar information affect farmers' behaviour (e.g., Wallander et al., 2017;

[1] Causal chain: Information $\rightarrow$ Expectations $\rightarrow$ Attitudes $\rightarrow$ Behaviour.

Laepple et al., 2022).

In this paper, we explore how the provision of information affects farmers' expectations and their subsequent attitudes towards clover adoption. To this end, we used an information experiment with dairy farmers in Ireland. This allowed us to estimate a causal effect of information on farmers' expectations. Then, as for the subsequent attitudes, we study the effect of farmers' adjusted expectations on farmers' intentions to adopt and willingness to accept (WTA) clover. In parallel, we explore the role of a scientific and a peer frame in treatment effects. We hypothesize that information will induce farmers to update their expectations and increase their expected reduction in chemical N fertilizer application related to clover adoption. This update in expectations is anticipated to increase farmers' intentions to adopt clover, and decrease their WTA. Ultimately, the peer information frame is expected to be more effective than the scientific frame.

The paper is organized as follows. Section 2 explains the background, remarking on the importance of focusing on the Irish dairy sector, and the introduction of clover into grazing grass. Section 3 presents the design of the experiment, the description of our sample, and it walks through the main methods of analysis. We then present the results in section 4, followed by concluding remarks in the last section.

2 Background

2.1 Irish dairy sector

The Irish dairy sector depends on a production system based on spring calving and mainly grazing pasture. This sector experienced a significant expansion initiated post the abolition of the EU milk quota in 2015. Dairy cow numbers and milk production increased by 50% and 74% respectively, between 2010 and 2021 (Central Statistics Office [CSO], 2023b, 2023d). This expansion had implications for farm and aggregate-level chemical N fertilizer application rates, and by extension environmental emissions. For example, between 2010 and 2021, the GHG emissions from Irish agriculture increased by 17% (EPA, 2022b). In this period, national application of chemical N fertilizer increased by 18%, from 337,574 tonnes (t) in 2010, to 399,164 t in 2021 (CSO, 2023c). In 2020, the dairy sector was responsible for over 50% of national chemical N fertilizer application (DAFM, 2020).

To address the negative environmental impact of the agricultural expansion, the Irish Climate Action Plan established sector-specific GHG mitigation measures. Measures such as reduced fertilizer usage, improved animal efficiency, expansion of organic and domestic biomethane industry, and provision of diversification options[2] for livestock farmers (DECC, 2022). Their adoption is key for the agricultural sector to achieve the 25% reduction target of GHG emissions by 2030, relative to 2018. Besides the introduction of clover into grazing grass, the following farm practices are also included to reduce fertilizer usage: multi-species swards, protected urea, liming, low emissions slurry spreading equipment, and improved nutrient management planning (Lanigan et al., 2018; Fitzmaurice, 2022). These practices are non-excludable, and sometimes their combination is recommended (DECC, 2022).

In 2022, it was evidenced that the reduction of chemical N fertilizer application can significantly decrease GHG emissions from agriculture. That year, a 14% reduction in chemical N fertilizer usage, driven by high fertilizer prices, led to a 1.2% decrease in GHG emissions from agriculture relative to 2021 (EPA, 2022b). This stresses the importance to promote farm practices that can reduce fertilizer application. To this end, the government has also launched initiatives (e.g., AgNaV, Signpost Programme) that support farmers with the adoption of such farm practices.

2.2 Introduction of clover into grazing grass

The adoption of clover is a key practice for a dairy farm as it has high potential to improve environmental and economic performance. Traditionally, Irish dairy farms use pure perennial rye-grass swards. Clover can be established[3] in the sward to reduce dependence on chemical N fertilizer, due to its N fixation capacity and use efficiency (Caradus et al.,

[2] e.g., anaerobic digestion, forestry, and tillage.

[3] Recommended species include white clover, or red clover. There are three ways of implementing clover swards: direct reseeding, over-sowing, and promoting the existing clover. It is recommended to employ all these methods when converting a farm over to clover (Humphreys & Lawless, 2006).

2013; DECC, 2022). Clover also involves low emissions of ammonia and N_20, increased carbon sequestration compared to traditional perennial rye-grass, rapid uptake of recycled N from animal excreta and it improves animal health for its high nutritive and feeding value (Caradus et al., 1995; Ledgard et al., 2009; Humphreys et al., 2012; Lanigan et al., 2018).

Aside from its environmental benefits, clover adoption comprehends considerable economic benefits, such as increased productivity and reduced costs of production. On the one hand, it increases productivity by improving animal feed intake[4], their utilization rates and by providing additional mass forage with more herbage dry matter available for grazing or silage conservation (Caradus et al., 1995; Andrews et al., 2007; Egan et al., 2018). On the other, it reduces costs of production by diminishing the application of expensive chemical N fertilizer[5]. The importance of focusing on this practice becomes clear given the multitude of benefits it brings. Beyond Ireland, in the European transition towards environmentally sustainable dairy farms, more studies about clover adoption have emerged in France (e.g., Rouillé et al., 2022), Germany (e.g., Reinsch et al., 2020), and the Netherlands (e.g., Alderkamp et al., 2024).

Nonetheless, there are costs of clover adoption that are worth mentioning. These include direct costs of establishment[6], and maintenance costs (e.g., over-sowing with clover seeds every five years[7], or the cost of clover safe sprays to control weeds (Buckley et al., 2020)). In addition, there are labour and learning costs associated. The introduction of clover requires a high level of management to be successfully established and retained. Thus, farmers are likely to spend more time ensuring optimal growth conditions[8] and giving maintenance. They may also need guidance and education in terms of clover management (Andrews et al., 2007). Additionally, there are a number of risks associated with the uptake of clover, such as failed incorporation and management, uncontrolled weeds,

[4]Clover has a low resistance to chewing which can result in an estimated 10% to 35% higher intake, compared to perennial rye-grass (Caradus et al., 1995).

[5]As of December of 2022, the price of CAN fertilizer was €870 per tonne. This represents an increase of 278% relative to 2020 (CSO, 2023a).

[6]Estimated at €116.14 per hectare for reseeding with clover (Buckley et al., 2020).

[7]Clover begins to decline after four or five years. Over-sowing rotation is required to maintain the persistency in swards(Humphreys & Lawless, 2006).

[8]Soil pH must be over 6.3, and Index 3 for phosphorus and potassium(Buckley et al., 2020).

pests (e.g., leatherjackets, wireworms, and frit flies), and bloat[9] in cattle (O'Connor, 2012; Buckley et al., 2020).

3 Methodology

3.1 Experimental design

We designed an information experiment embedded in a survey using Qualtrics (Qualtrics, 2005). The survey[10] included farm characteristics, the randomized information experiment, farmers' environmental attitudes, and their socio-economic characteristics. Our experimental design and hypotheses were pre-registered on Open Science Framework[11]. In addition, the experiment had ethical approval from the Ethics Committee of the University of [REDACTED][12].

The experimental design consisted of four stages (see figure 1). In the first stage, farmers' expectations about clover adoption were elicited before treatment (i.e., farmers' prior expectations). We combined a qualitative and quantitative measurement of expectations as suggested by Haaland et al. (2023). Qualitatively, the following open-ended question was asked:

"*The current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.*
When you hear this recommendation, please let us know what comes to your mind?".

We adhered to the recommendations proposed by Ferrario and Stantcheva (2022) when designing this question. Use of this question was important to capture farmers' first-order expectations[13], concerns, and considerations when thinking about clover adoption. Open-ended questions are also useful to identify fraudulent responses (Goodrich et al., 2023).

[9] There are two types of bloat: gassy, which is caused by gullet blockage, and frothy, linked with high content of clover in swards (McDonnell, 2021).
[10] Full survey can be found in appendix A.19.
[11] Available here [REDACTED].
[12] Reference number: [REDACTED].
[13] Or first-order beliefs; refers to the farmers' intrinsic beliefs about clover adoption.

Then quantitatively, respondents provided a point estimate under the following hypothetical scenario of adoption:

"*The current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.*

Imagine you had implemented this recommendation on your farm. How much do you think your application of chemical nitrogen fertilizer would change?".

Available answer choices were: "*Increase by:*", "*Decrease by:*", and "*No change in fertilizer application*". If "*Increase by:*" or "*Decrease by:*" were selected, then participants were asked to provide a point estimate. This measurement resembles Armantier et al. (2017) on the elicitation of expectations for continuous outcomes.

In the second stage, participants were randomly assigned into one of three groups: two groups designated for treatment, and one group for control. In the literature on information experiments, scant attention has received the impact of information framing on behaviour (e.g., Banerjee et al., 2020; Bernard et al., 2022; Dylong and Koenings, 2023). Therefore, while farmers in our treatment groups were exposed to the same factual information about clover, the framing of the information was different in each treatment group. The first treatment group was given a scientific frame where information was based only on scientific studies. Participants under the first treatment condition were exposed to the following information:

"***Scientific studies*** *show that by establishing at least 20% clover content in all of a farm's grassland area,* ***it is possible to reduce chemical nitrogen fertilizer by 90%****.*

Based on those scientific studies*, for the average dairy farmer, this would mean that chemical nitrogen fertilizer application can be reduced from* ***166.6 kg N/ha*** *to* ***16.6 kg N/ha****.*

(Figures are based on 2021 average chemical nitrogen fertilizer application rates of dairy farmers in Ireland)".

The second treatment group received a peer frame. We kept the factual information presented in the first treatment constant, but we included a sentence that mentioned other farmers' experiences with clover. Farmers assigned to the second treatment were shown the following information:

"***Scientific studies*** *show that by establishing at least 20% clover content in all of a farm's grassland area,* ***it is possible to reduce chemical nitrogen fertilizer by 90%****. Some* ***dairy farmers*** *who have established this clover content on their farms were able to reduce chemical nitrogen fertilizer application.*

Based on those scientific studies*, for the average dairy farmer, this would mean that chemical nitrogen fertilizer application can be reduced from* ***166.6 kg N/ha*** *to* ***16.6 kg N/ha****.*

(Figures are based on 2021 average chemical nitrogen fertilizer application rates of dairy farmers in Ireland)".

This approach allows for comparisons between treatments, and draws upon the treatments of Coibion et al. (2018). Thus, all participants that received treatment were shown that clover adoption at the recommended level can reduce chemical N fertilizer use by 90%. This reduction percentage was calculated based upon the studies of Hennessy et al. (2019, 2022), that achieved a reduction of 150 kg N/ha in chemical N fertilizer application when adopting clover[14].

For participants who were randomly assigned to the control group, we used an active control strategy. Thus, information that was not related to our outcome variables was presented to farmers in the control group. We showed them the following 'fun fact'[15] about clover:

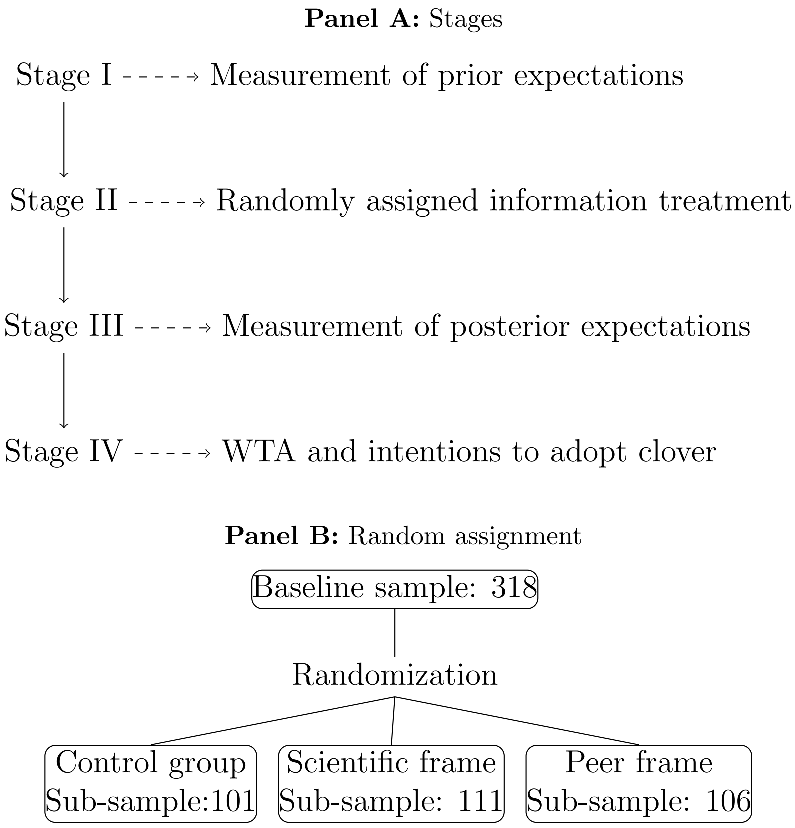
"*Clover can have more than four leaves. The highest ever recorded is a 56-leaf clover found by farmer Shigeo Obara in Japan. He was awarded the Guinness World Record in 2009. While some say that 4-leaf clovers symbolize good luck, and 5-leaf clovers symbolize wealth, it is unclear what a 56-leaf clover symbolizes.*".

[14]It is worth mentioning that in the clover literature, there have been different reductions in chemical N fertilizer application. Some found a reduction by 100 kg N/ha (e.g., Egan et al., 2015; Egan et al., 2018), others by 200 kg N/ha (e.g., Byrne, 2023; DAFM, 2023), and others even a total reduction in the application of chemical N fertilizer (e.g., Humphreys et al., 2017; Scully et al., 2021).

[15]References for the 'fun fact': Yomiuri, 2008; Guinness World Records, 2009.

In the third stage, all respondents' qualitative and quantitative expectations were re-elicited. At this stage, the same questions used for the prior expectations were asked again to establish farmers' posterior expectations. Finally, at the fourth stage, we captured farmers' WTA clover, and intentions to adopt. Regarding WTA, farmers were asked how much fertilizer savings would definitely motivate them to establish the recommended level of at least 20% clover content in all of their farm's grassland area. Available answer choices were: "*€/ha:*", "*€ (total farm):*", and "*Regardless of savings, I would not establish clover at the recommended level*". Those who selected "*€/ha:*" or "*€ (total farm):*" were required to state a value. Sometimes, elicitations of WTA/WTP use dichotomous choice, or payment card methods (e.g., Fuster and Zafar, 2015; Adams-Prassl et al., 2023); but we opted to use a point estimate (e.g., Hoffman, 2016; Cullen and Perez-Truglia, 2018; Bernard et al., 2022), so that responses are not limited to a particular scale that could cause priming. Then, intentions to adopt clover were measured using a probabilistic approach. Each participant was asked about their probability to establish at least 20% clover content in all of their farm's grassland area within the next five years.

Figure 1: Experimental design



3.2 Data

The survey experiment was conducted from the 23rd of January 2023 to the 28th of February 2023. Data collection was restricted to dairy farmers in the Republic of Ireland, and to incentivize participation, we offered a draw of thirty €50 vouchers. The main channel to recruit participant dairy farmers was through Teagasc's[16] farm advisors. Additionally, an online link to the experiment was posted in popular farming press[17], and farmers were directly approached at a farming conference[18]. We recorded 1,097 responses, including completed, uncompleted, and fraudulent responses. On the morning of the 30th of January, we received fraudulent responses from an automated bot[19]. After cleaning recordings using the guidelines of Goodrich et al. (2023), responses from 318 dairy farmers were deemed useful for analysis[20].

Table 1 shows the characteristics of the full sample. On average, farms had a size of 81 hectares and a herd size of 137 dairy cows. Hence, our farm sample is considerably[21] larger than the 2022 national average of 65 hectares, and herd size of 93 dairy cows (Dillon et al., 2023). Similarly, the average application of chemical N fertilizer[22] from our sample was 222.30 kg N/ha in 2022, significantly higher than the 2022 national average of 156.8 kg N/ha (Buckley, 2023).

A key control variable that requires further explanation is the existing clover content in a respondent's grassland area. To capture the clover content we used a constant-sum question where we asked what percentage of the grassland area in 2022, had the following clover content options: "*0% clover*", "*1-4% clover*", "*5-9% clover*", "*10-14% clover*", "*15-19% clover*", and "*20% clover or more*". Answers added to 100% (e.g., 80%

[16]Irish Agriculture and Food Development Authority.

[17]First, we placed a digital advert in Agriland; then, we received media coverage by the Irish Farmers Journal.

[18]See distribution in appendix A.14.

[19]Identified most likely as an alias fraud (i.e., single individual submitting multiple responses) (Goodrich et al., 2023).

[20]Steps of data cleaning are in appendix A.10.

[21]Before collecting data, we anticipated this to happen based on previous experiences (e.g., Läpple, 2023; Läpple and Osawe, 2023), and on the data collection procedure.

[22]To some farmers, the application of chemical N fertilizer might have been difficult to answer. Therefore, farmers were allowed to indicate a value in their preferred measure, and then, the level of certainty in their response. The majority of farmers (63.21%) indicated they certainly knew this value. To account for outliers, we winsorized responses at the 95-percentile. We replaced only six incorrect entries with the national average of 2021.

of the grassland area on the farm could have 0% clover content, and 20% could have 5-9% clover content). For the analysis, we used the weighted average from responses, ranging from 0% to 20%. The average clover content was 6.10% in the full sample. Only four farmers in the total sample have actually adopted the recommended level of 20% clover content in all of the farm's grassland area.

Table 1 also presents the descriptive statistics by treatment groups. A Kruskal-Wallis test confirms that the means across groups are not significantly different. This shows that the randomization worked properly, as such, farmers' observable characteristics are balanced between treatment and control groups.

Table 1: Descriptive statistics of control variables

	Control group	**T1: Scientific Frame**	**T2: Peer Frame**	**Full sample**
Farm size (ha)	84.09	74.87	84.57	81.03
	(57.89)	(44.37)	(72.10)	(59.02)
Herd size (# cows)	141.65	127.27	141.32	136.52
	(120.32)	(83.33)	(87.70)	(97.83)
Stocking rate (Farm size/Herd size)	1.71	1.77	1.82	1.77
	(0.58)	(0.62)	(0.60)	(0.60)
Fertilizer application‡ (kg N/ha)	212.47	220.51	233.53	222.30
	(155.65)	(160.76)	(157.59)	(157.83)
Clover content (% weighted average)	6.06	5.73	6.51	6.10
	(4.83)	(4.67)	(4.62)	(4.70)
Environmental attitudes^{1†} (score 1-5)	3.69	3.76	3.85	3.77
	(0.91)	(1.10)	(1.06)	(1.03)
Age† = 1 if older than 46 y/o (%)	53.47	49.55	44.34	49.06
Gender† = 1 if male (%)	92.08	93.69	92.45	92.77
Knowledge transfer engagement† = 1 if involved (%)	79.21	77.48	80.19	78.93
General education† = 1 if $\geq 3^{\text{rd}}$ level (%)	22.77	31.53	27.36	27.36
Agricultural education† = 1 if $\geq 3^{\text{rd}}$ level (%)	27.71	23.23	31.53	27.88
Observations:	101 (†99)	111	106 (†104)	318 (†314)

Notes: Standard deviations are reported in parentheses. Means across groups are not significantly different (t-tests and Kruskal-Wallis tests were made). [1]Cronbach's alpha: 0.61. †Indicates a different number of observations. ‡Responses were winsorized at the 95-percentile to reduce the effect of outliers.

3.3 Methods of analysis

Our main outcome variables are farmers' prior and posterior expectations around clover adoption, intentions to adopt clover, and their WTA clover. As mentioned, farmers' prior and posterior expectations were elicited using quantitative and qualitative measurements. From the quantitative expectations, initial descriptive results are obtained by calculating the updated expectations, and the misperceptions. The updated expectations (ΔExp_i) are the difference between the posterior and prior expectations. Misperceptions are defined as the difference between the actual value presented in our treatments and the prior expectations (e.g., Stantcheva, 2021; Fuster et al., 2022). In the econometric analysis, we estimated treatment effects using a two-stage least squares regression (2SLS) (e.g., Roth et al., 2022; Schnorpfeil et al., 2023). In the first stage, we estimated treatment effects on farmers' updated expectations:

$$\underbrace{(Exp_{i,post} - Exp_{i,prior})}_{\text{Updated Expectations } (\Delta\hat{E}xp_i)} = \alpha + \sum_{s=1}^{S} \beta_s Treat_{s,i} + \varepsilon_i \tag{1}$$

where i indexes respondents, $Exp_{i,post}$ and $Exp_{i,prior}$ are expectations about clover adoption, post and prior treatment, respectively. $Treat_{s,i}$ is a categorical variable equal to one if respondent i received information treatment with a scientific frame, equal to two if received information treatment with a peer frame, and zero if participants were randomly assigned to the control group. The β_s coefficients provide an estimate of the average effect of each treatment on the change in the expectations relative to the control group.

In the second stage, we examine how the information treatment affects farmers' intentions and WTA through their updated expectations. The predicted updated expectations ($\Delta\hat{E}xp_i$) of the first stage, are used as regressand of the intentions (equation 2), or of the willingness to accept (equation 3):

$$Intentions_i = \alpha + \beta_1 \Delta\hat{E}xp_i + \varepsilon_i \tag{2}$$

$$WTA_i = \alpha + \beta_1 \Delta\hat{E}xp_i + \varepsilon_i \tag{3}$$

The β_1 coefficients measure the average effect of the updated expectations, driven by the information treatments, on intentions and WTA. This 2SLS strategy assumes that the information treatments only affect intentions and WTA, through their effect on expectations[23](i.e., instrument exogeneity assumption). In contrast to a 'naive' regression of intentions or WTA on the updated expectations, using both information treatments as instrumental variable for the updated expectations helps to reduce concerns about

[23]Our information treatments satisfy the instrument relevance and exogeneity assumptions. Relevance is satisfied, as shown in table 3; and exogeneity is satisfied because the information treatments were randomly assigned.

omitted variables that could affect both intentions or WTA. Naturally, a vector Z_i is added to all equations when including our control variables.

In parallel, as for the qualitative expectations, a text analysis was done from which descriptive and inferential results are obtained. We employed three text-analysis methods: wordclouds, keyness, and topic analyses. While the wordclouds and keyness share the same automated pre-processing steps[24], we did a hand-coding of responses for the topic analysis[25]. The first pre-processing step for the wordclouds and keyness analyses, involved trimming down the responses from the open-ended questions. For this purpose, we removed punctuation, 'stop words'[26], we lemmatized the inflected forms of a word, and removed words that are structurally part of answers[27]. In the second pre-processing step we created the document-term matrix (i.e., matrix of frequencies of terms in each answer). For the hand-coding of responses, we first identified the specific elements mentioned in each response, and then we aggregated them into broader categories[28].

Lastly, we created a new categorical variable to capture the change in opinions from the prior to the posterior expectations. Thus, this variable represented the updated qualitative expectations. To this end, we examined prior and posterior expectations and, without observing whether subjects received treatment or not, we categorized their update of expectations into: a 'positive change in opinions', a 'negative change', 'no change, but keeping a general positive opinion', and 'no change, but keeping a general negative opinion'. As a guideline for our categorization, a positive change was considered if the prior response of a farmer was focused first on an issue related to clover adoption or on disagreement with the adoption recommendation, and then the posterior response of a farmer was centered around a benefit from adoption or agreement with the adoption recommendation or any intention to adopt. The opposite was considered a negative change.

[24] The wordclouds and keyness analyses were done using the package by Benoit et al. (2018). The motivation to use it came from Stantcheva (2021) and Ferrario and Stantcheva (2022).

[25] Similar to Bursztyn et al. (2020) and Andre et al. (2022).

[26] Common words without intrinsic meaning (e.g., personal pronouns).

[27] Example of words: level, sward, clover, farm, grass, etc. Full list of words can be found in R scripts of figures 2, and 3, in the replication folder.

[28] See appendix A.4.

For example, the prior expectation of one participant mentioned: "*Awful labour intensive*". But, the posterior expectations of this participant was: "*Would be well worth it to reduce fertilizers*". Therefore, this farmer's updated expectation was categorized as a positive change. In contrast, another participant stated in the prior expectation: "*Reduction in chemical fertilizer*". However, the posterior expectations of this participant was: "*The cost of reseeding the clover and maintaining it in the sward*". Thus, this farmer's updated expectation was categorized as a negative change.

Notice that while the open-ended questions were displayed to all farmers, these did not require an answer to continue with the survey. Hence, it was assumed that a farmer did not have a change in opinions if an open-ended question was left without response. In addition, we double-checked our categorization using the AI tool ChatGPT (OpenAI, 2022). The standard chat message that was used for each subject is included in appendix A.9. We observed a substantial inter-rater reliability[29] of 68.77% (Landis & Koch, 1977).

Using OLS regressions, we estimated the treatment effects on the updated qualitative expectations. The categories of the updated qualitative expectations, were then used as dependent variables in equation 1. These dependent variables are binary, equal to one to indicate each category of the updated qualitative expectations, and zero otherwise.

4 Results and Discussion

4.1 Descriptive Results: Quantitative Expectations

We start by presenting the descriptive statistics of our outcome variables in table 2. The first three columns report results by treatment groups, and the last column corresponds to the full sample. At the top of the table, prior expectations show that farmers underestimated the reduction in chemical N fertilizer application associated with clover adoption at the recommended level. On average, farmers' prior expectations denoted a perceived reduction of 20.50% in chemical N fertilizer application rates (last column). As such,

[29] The residual category 'other' was not included in the inter-rater reliability. Before solving conflicts, the initial inter-rater reliability was of 62.45%, still under the substantial agreement range. We evaluated again our categorization in cases of conflicts. Then, the revised classification was considered for the analysis of results. The inter-rater reliability of the revised classification is the one presented above.

being 69.50% away from the 90% reduction figure shown in the treatments.

In contrast, the average posterior expectation of the full sample was 30.71%. With a significantly[30] higher reduction under the scientific (33.99%) and peer (37.59%) frames, than the unaltered control group (19.87%). Accordingly, this is reflected in higher updated expectations for the scientific (15.42%) and peer (17.04%) frames, compared to the control group (-2.69%).

At the bottom of table 2, farmers' average intentions stated a 55.25% probability to establish the recommended level of clover content on their farms. Results indicate that intentions of the active control group were higher than in the treatment groups. We believe that the information presented in the active control might have been more enjoyable than the information presented in treatment groups. Regardless, average intentions across groups were not significantly different.

At last, values for WTA were € 132.1/ha in the control group, € 150.91/ha in the scientific frame, and €175.98/ha in the peer frame. Before collecting data, we were expecting that the WTA was going to be lower in treatment groups than in the control group. However, means for WTA in treatment groups were significantly higher than in the control group. We intuit that farmers' desired savings from clover are higher once they realize how much fertilizer they can cut when adopting clover. But, once again, means for WTA were not significantly different between groups.

[30] t-tests by groups in appendix A.2. Notice that differences across means of the scientific and the peer frame were not statistically significant.

Table 2: Descriptive statistics of outcome variables

	Control group	T1: Scientific Frame	T2: Peer Frame	Full Sample[1]
Prior expectations (%)	22.56	18.57	20.56	20.50*
	(16.32)	(22.10)	(18.09)	(19.10)
Misp. = (90%) - Prior Exp.	67.44	71.43	69.44	69.50*
	(16.32)	(22.10)	(18.09)	(19.10)
Posterior expectations (%)	19.87	33.99	37.59	30.71***
	(20.71)	(40.46)	(39.50)	(35.74)
Updated expectations (%)	- 2.69	15.42	17.04	10.21***
	(17.21)	(36.55)	(37.03)	(33.00)
Intentions (% prob. of adoption)	58.26	52.59	55.15	55.25
	(29.80)	(32.64)	(32.11)	(31.57)
WTA[‡] (Savings in €/ha)	132.10	150.91	175.98	153.29
	(163.10)	(199.46)	(194.89)	(187.34)
Observations:	101	111	106	318

Notes: Standard deviations are reported in parentheses. [‡]Responses were winsorized at the 95-percentile. [1]Statistical significance based on Kruskal-Wallis test between the three groups: *p < 0.10; **p < 0.05; ***p < 0.01.

4.2 2SLS Results: Quantitative Expectations

Table 3 reports the regression results[31] of the updated expectations on the information treatments (i.e., equation 1). First, we pooled treatments in columns 1 and 2. Overall, providing information significantly increases farmers' updated expectations by 18.91% (column 1). When controlling for farmers' characteristics (column 2), this effect is 18.60%. Then, we estimated the treatment effects separately to analyze how the framing of information affects the updated expectations (columns 3 and 4). As shown in column 4, informing participants using a scientific frame significantly increases the expected reduction in chemical N fertilizer application by 17.62% on average relative to the control group. The effect is higher[32] when presented with a peer frame; where farmers increase their expected reduction by 19.64%. However, we cannot reject the null hypothesis that the two treatment coefficients are equal[33].

Next, in table 4 a first stage F-statistic of 17.47 confirms that both treatments are not a weak instrument for the second stage regression of intentions or WTA on the updated expectations[34] (i.e., equations 2 and 3).

[31]Robustness checks in appendix A.13.

[32]p-value of linear test $H_0 : \hat{B}_2 > \hat{B}_1$ equals 0.65.

[33]p-value of $H_0 : \hat{B}_2 = \hat{B}_1$ equals 0.67.

[34]Results of the OLS 'naive' regression of intentions or WTA on the updated expectations are presented in appendix A.11.

Table 3: Treatment effects on the updated expectations

	Stage I Updated Expectations			
	(1)	(2)	(3)	(4)
Information (T1 & T2)	18.91***	18.60***		
	(3.03)	(3.15)		
T1: Scientific Frame			18.12***	17.62***
			(3.87)	(4.03)
T2: Peer Frame			19.73***	19.64***
			(3.98)	(4.07)
Control variables[1]	No	Yes	No	Yes
R^2	0.07	0.09	0.07	0.09
Observations	318	316	318	316

Notes: Robust standard errors are reported in parentheses. Statistical significance: *p < 0.10; **p < 0.05; ***p < 0.01. [1]Control variables included: herd size, fertilizer application, clover content, environmental attitudes, age, gender, knowledge transfer engagement, and education in agriculture.

Results of equations 2 and 3 are presented in panel A of table 4, and their reduced-form is presented in panel B. Regarding farmers' intentions, there is not a significant effect either in the 2SLS, or in the reduced-form. As for WTA, while there is a significant coefficient in the reduced-form (under the peer frame in column 3), the effect does not hold when including our control variables, and in parallel, there is not an effect in the 2SLS.

As for discussion on this subsection, it could be argued that the adoption recommendation, of establishing at least 20% clover content in a farm's grassland area, might have been priming the update of expectations. Before the posterior expectations, this figure was shown three times to farmers in the treatment groups, and twice to those in the control group. Notice that the information effect on farmers' updated quantitative expectations is slightly close to 20% (table 3).

In the next subsection, we focus on the qualitative expectations, and we can observe that the number 20 appears in the wordclouds[35] of the posterior qualitative expectations in figure 2. But, it is not a keyword in figure 3. In addition, the recommendation of

[35]We intentionally did not exclude numbers from the text analysis.

adoption was mentioned again when asking farmers about their intentions, and WTA. However, mean values of intentions and WTA were not close to 20 in table 2.

Table 4: Treatment effects on intentions and WTA

	Intentions		**WTA**	
	(1)	(2)	(3)	(4)
Panel A: 2SLS				
Updated Expectations ($\Delta\hat{E}xp$)	-0.22	-0.22	1.72	1.41
	(0.20)	(0.20)	(1.11)	(1.14)
1^{st}-stage F stat	19.53	17.47	19.53	17.47
Panel B: Reduced-form				
T1: Scientific Frame	-5.66	-4.66	18.81	9.61
	(4.29)	(4.32)	(24.94)	(24.85)
T2: Peer Frame	-3.11	-3.88	43.88*	39.17
	(4.30)	(4.18)	(24.93)	(25.59)
R^2	0.01	0.10	0.01	0.07
Control variables[1]	No	Yes	No	Yes
Observations	318	316	318	316

Notes: Robust standard errors are reported in parentheses. Statistical significance: *p < 0.10; **p < 0.05; ***p < 0.01. [1]Control variables included: herd size, fertilizer application, clover content, environmental attitudes, age, gender, knowledge transfer engagement, and education in agriculture.

4.3 Descriptive Results: Qualitative Expectations

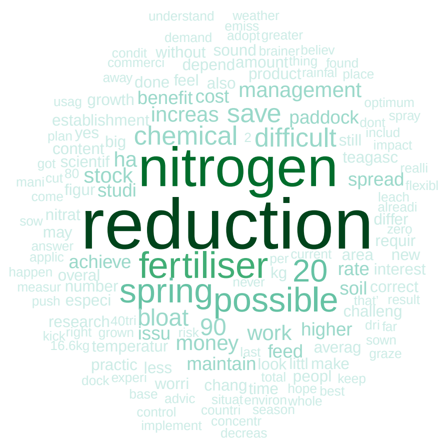
We begin with the wordclouds for the prior and posterior qualitative expectations that are presented in figure 2. It is worth recalling that both captured what comes to mind when farmers hear the current recommendation of clover adoption. In the wordclouds, the most frequent words used in responses are written in a larger font. In panel A (prior expectations), the words that appear more often in the answers include "*bloat*", "*difficult*", "*management*", "*establishment*", and so forth. Denoting good experimental control, words from panel A are similar to those from the posterior expectations of the control group in panel B. In contrast, when presented with the scientific information frame (panel C), the most used words in farmers' posterior expectations are different (e.g., "*reduction*", "*nitrogen*", "*fertiliser*", "*spring*", "*possible*", etc.). The posterior expectations under the peer frame (panel D) indicated similar results. Hence, wordclouds provide an initial descriptive insight that the most frequent words in farmers' responses changed after treatment.

Figure 2: Wordclouds for expectations

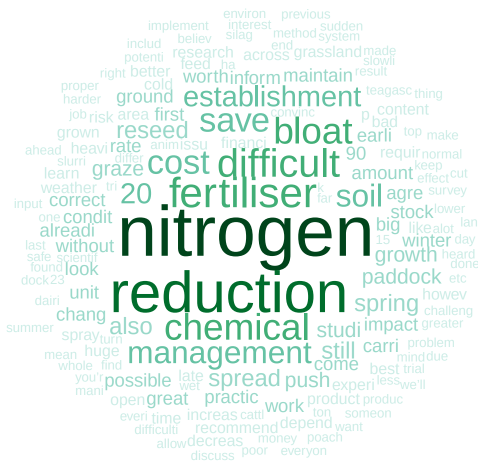
Panel A: Prior expectations of full sample

Panel B: Posterior expectations of control group

Panel C: Posterior expectations of treatment 1



Panel D: Posterior expectations of treatment 2



In relation to the keyness analysis, results are shown in figure 3. In the analysis, the relative frequencies[36] of words used in the prior and posterior expectations were compared. A χ^2 test was undertaken[37], and a word statistically significant is considered a keyword.

[36]Minimum term frequency was set to ten.

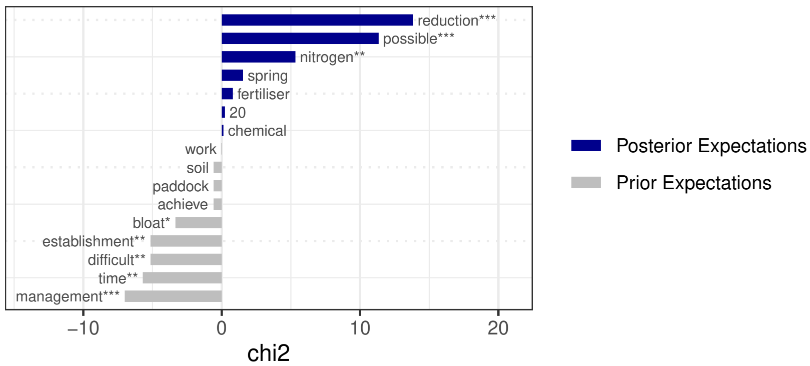
[37]Testing the null hypothesis that the occurrence of a word is equal across prior and posterior expectations.

Clear differences in the keywords between the prior and posterior expectations can be found in participants who were exposed to the first (scientific frame) and second (peer frame) treatments.

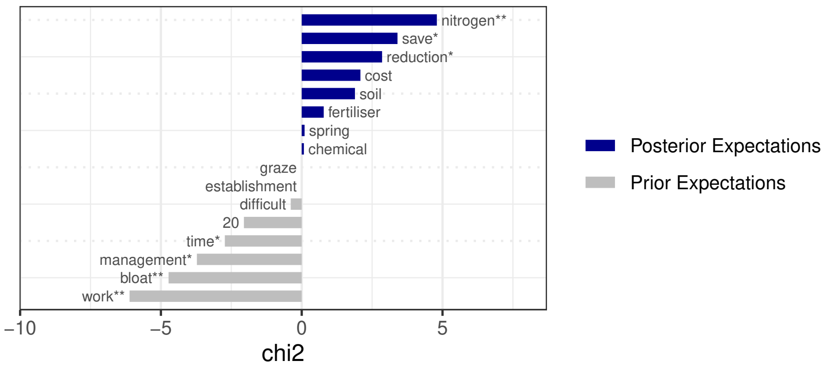
For participants in the scientific frame (panel A), keywords on the prior expectations are centered around issues or concerns with clover adoption: "*management*", "*time*", "*difficult*", "*establishment*", and "*bloat*". Meanwhile, keywords on the posterior expectations are related to benefits from adoption, or to the information treatment: "*reduction*", "*possible*", and "*nitrogen*". Keywords from responses in the peer frame (panel B) are quite similar, with only two distinctions: "*work*" and "*save*". "*work*" is considered a keyword, and is significantly more frequent in the prior expectations than in the posterior expectations. In contrast, after receiving information, "*save*" appears as a keyword related to a benefit from adoption. Again, showing good experimental control, there is no significant difference across the frequencies of words used in the prior and posterior expectations of the control group (panel C). Next, the hand-coding of responses for the topic analysis will give us more context of the most frequent elements that were mentioned in prior and posterior expectations.

Figure 3: Keyness analysis within treatment groups

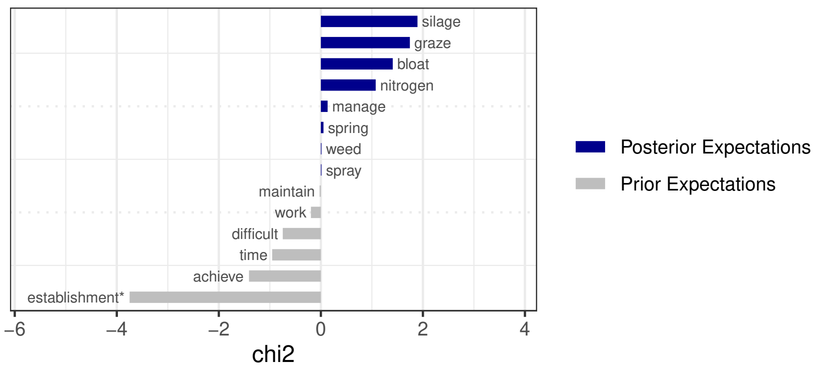
Panel A: Prior vs. posterior expectations of treatment 1 (scientific frame)



Panel B: Prior vs. posterior expectations of treatment 2 (peer frame)



Panel C: Prior vs. posterior expectations of control group



Notes: Statistical significance based on χ^2 test between groups: *p $<$ 0.10; **p $<$ 0.05; ***p $<$ 0.01.

The frequencies of the broader categories defined in the topic analysis[38] are presented in figure 4. The elements[39] contained in each category can be found in appendix A.4, and relative frequencies of figure 4 are presented in appendices A.6 and A.7. In the prior expectations (panel A), the most frequent category mentioned was clover management issues (29.25%). However, the frequencies of this category are lower in the posterior expectations (panel B), for participants in the first and second treatment (16.22% and 17.92%, respectively). Similarly, animal health issues were more remarked in the prior expectations of the treatment groups (≈16% in each treatment group), than in their posterior expectations (8.11% in the scientific frame, and 11.32% in the peer frame).

Perceived benefits from adoption occurred more in the posterior expectations of the treatment groups (15.32% in the scientific frame, and 24.53% in the peer frame), than in their prior expectations (<10% in each treatment group). However, agreement with the current recommendation of adoption was less frequent in the posterior expectations of the treatment groups (13.51% in the scientific frame, and 12.26% in the peer frame), than in their prior expectations (>25% in each treatment group). Overall, frequencies in categories have changed considerably[40] when exposed to the information treatments.

In relation to the updated qualitative expectations, figure 5 and appendix A.8 illustrate the frequencies of each category. The majority of farmers did not change their opinions, including those given treatment. Over a third of farmers under treatment, kept a negative opinion about clover adoption (43.24% of treatment one, and 34.91% of treatment two). On the one hand, 15.32% of farmers assigned to the first treatment (scientific frame), and 19.81% under the second treatment (peer frame), had a positive change in their opinions. On the other hand, a negative change in opinions was found in 11.71% of farmers in treatment one, and in 15.09% of farmers in treatment two.

It prompts consideration as to whether disparities exist in farmers' characteristics across the categories of the updated qualitative expectations, or what are their quantitative expectations. Appendix A.12 shows the descriptive statistics of the control and

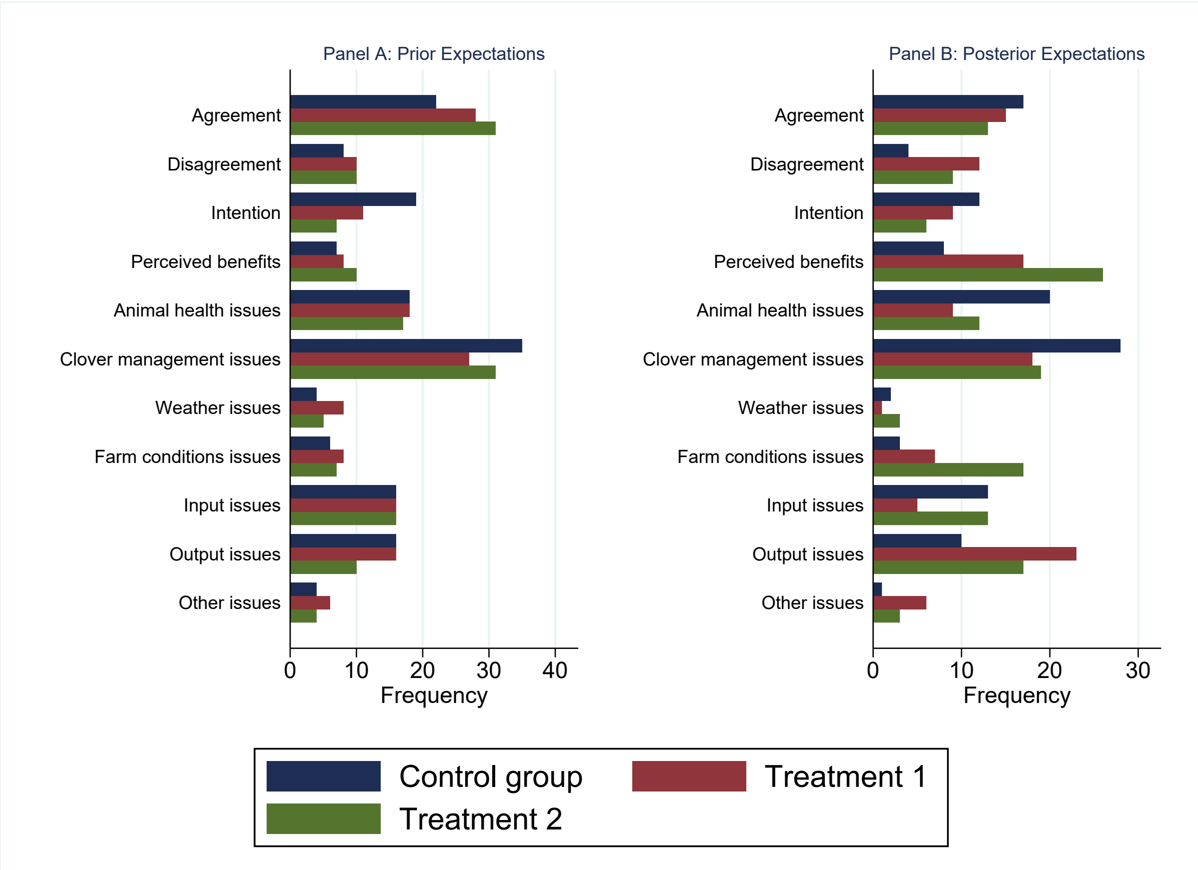
[38]These categories were also used for responses of survey question 8: 'Reasons for having low clover content' (appendix A.5).

[39]Note that a single response could include more than one element.

[40]Note that a Pearson's χ^2 test was made in appendices A.6 and A.7.

outcome variables by the categories of the updated qualitative expectations. Minor differences were found in farmers' characteristics[41]. Regarding the outcome variables, it's worth noting that even though some farmers had a negative change in their opinions, their posterior quantitative expectations are still higher than those farmers who did not change their opinions. Hence, the category of a negative change in opinions can also include farmers who believe in clover adoption. It is important to recall that the sole purpose of this category is to capture how qualitative responses changed negatively before and after treatment.

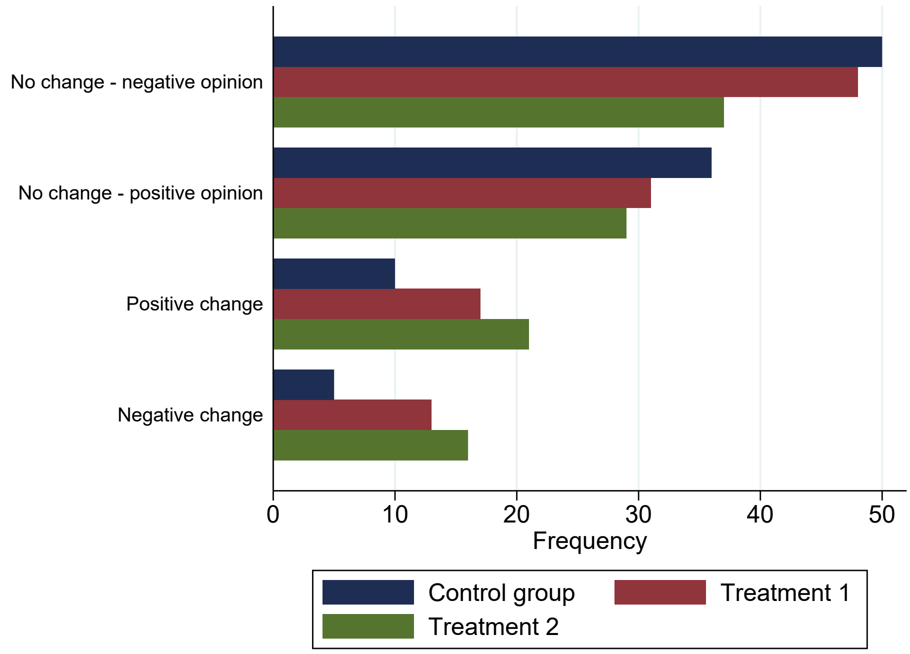
Figure 4: Topic analysis: prior vs. posterior expectations



Notes: Categories in common are included in the figure. Frequencies for all categories are available in appendix A.6 and A.7.

[41]For the control variables, Kruskal-Wallis test shows that means across groups are significantly different only for the stocking rate, and the clover content. t-tests between groups are presented in table A.3 (e.g., farmers in the 'positive change' group have a more concentrated stocking rate than farmers in both 'no change' categories).

Figure 5: Response types in the open-text data: updated expectations



4.4 OLS Results: Qualitative Expectations

As the last step of our analysis, we estimated an OLS regression of the updated qualitative expectations on the information treatments. Results are presented in table 5. Overall, participants exposed to treatment are more likely to have a positive, and a negative change in their opinions around clover adoption, relative to the control group (columns 3 and 4). The scientific frame increases by 8% the probability of having a positive change in opinions, and by 7% a negative change. Participants under the peer frame, are 12% more likely to have a positive change in their opinions, and 10% more likely to have a negative change in their opinions. The other two significant coefficients in columns 1 and 2, just imply that participants receiving the peer frame are less likely to have no change in their opinions. In particular, these participants are 13% less likely to keep a general negative opinion, and 11% less likely to maintain a general positive opinion.

Treatment effects on the updated qualitative expectations are small. Nonetheless, this aligns with the frequencies of farmers that were associated with a positive and a negative change in opinions, which were small. In total, just 46 farmers were identified with a positive change in their opinions, and only 34 with a negative change.

Table 5: Treatment effects on updated qualitative expectations

	OLS			
	Updated qualitative expectations			
	No change - negative	**No change - positive**	**Positive change**	**Negative change**
	(1)	(2)	(3)	(4)
T1:Scientific Frame	-0.07	-0.09	0.08*	0.07*
	(0.07)	(0.06)	(0.04)	(0.04)
T2: Peer Frame	-0.13*	-0.11*	0.12***	0.10**
	(0.07)	(0.06)	(0.05)	(0.04)
Control variables[1]	Yes	Yes	Yes	Yes
R^2	0.07	0.06	0.04	0.04
Observations	316	316	316	316

Notes: Robust standard errors are reported in parentheses. Statistical significance: *p < 0.10; **p < 0.05; ***p < 0.01. [1]Control variables included: herd size, fertilizer application, clover content, environmental attitudes, age, gender, knowledge transfer engagement, and education in agriculture.

To sum up this section, our main findings are: i) before receiving any treatment, farmers believed that clover adoption decreases chemical N fertilizer application by 20.50% (table 2); ii) information treatments increase this expected reduction by a further 18.60% (table 3); iii) farmers' opinions on clover were focused mainly on management issues (figure 4); and iv) information treatments increase the probability of having a positive, and a negative change in farmers opinions (table 5).

5 Conclusions

This paper explored how information provision affects farmers' expectations about a key GHG mitigation practice: the introduction of clover into grazing grass. Then, we studied the effect of farmers' adjusted expectations on intentions to adopt and WTA clover. To establish causality, we conducted a randomized information experiment with 318 dairy farmers in Ireland. We developed two information treatments and one active control group. The treatments provided information about fertilizer savings with clover, based on different framings (i.e., scientific and peer frames). Our experimental design is novel as we combined quantitative and qualitative expectations measurement. Therefore, besides the conventional analysis of quantitative expectations, we also employed three text analysis methods to examine qualitative expectations (i.e., wordclouds, keyness, and topic analyses).

Regarding the quantitative expectations, we document that farmers underestimate the reduction of chemical N fertilizer that can be achieved with clover adoption. Not only does this represent an important barrier for adoption, but it also suggests that farmers have weak incentives to learn about clover and improve the accuracy of their expectations. As hypothesized, information interventions can correct farmers' misperceptions about clover adoption, and increase their expected reduction of chemical N fertilizer by 18.60%. However, farmers receiving the scientific frame reacted similarly to those exposed to the peer frame. In addition, we did not find a significant effect of the updated expectations on intentions and WTA. Yet, intentions are not equal to final adoption decisions, and information provision is not a panacea to identify causal effects of adjusted expectations on subsequent self-reported attitudes (Fuster & Zafar, 2023).

Qualitative expectations led to the discovery of additional results. Before treatment, we found that the majority of farmers focus their attention on issues of adoption, especially on those related to clover management and animal health. When exposed to treatment, we discovered positive and negative changes in farmers' opinions. Combining a quantitative and qualitative measurement of expectations allowed us to have a deeper understanding of our treatment effects. While participants with a negative change in opinions do not necessarily underestimate the expected reduction in chemical N fertilizer associated with clover, this negative change in opinions might crowd-out adopters.

These findings point towards two important policy recommendations. Our first policy recommendation is to promote the existing financial incentives to adopt clover (e.g., DAFM, 2023). These incentives are most likely unknown by farmers. Awareness of these incentives may induce farmers to put more effort into accessing information about clover, and improving the accuracy of their expectations. Our second policy recommendation is to implement information campaigns about clover as they can improve expectations, and support farmers' adoption. Importantly, information about clover not only should highlight benefits from adoption, but also focus on mitigation of concerns (i.e., weeds control, bloat prevention, maintenance, etc.). Ignoring the issues around clover adoption when providing information to farmers could be a serious mistake and hinder adoption rates.

Finally, a possible limitation related to our study may be the persistence of treatment effects over time. Since we did not run a follow-up survey with participants, we cannot assure that treatment effects will hold in the long run. Also, a follow-up survey would have dismissed any potential priming of responses. Another shortcoming may be that the frames of information had similar effects. Further research on different frames of information is still needed. Even though internet connection might be an impediment in some farms, we encourage future experiments to include video treatments rather than standard text.

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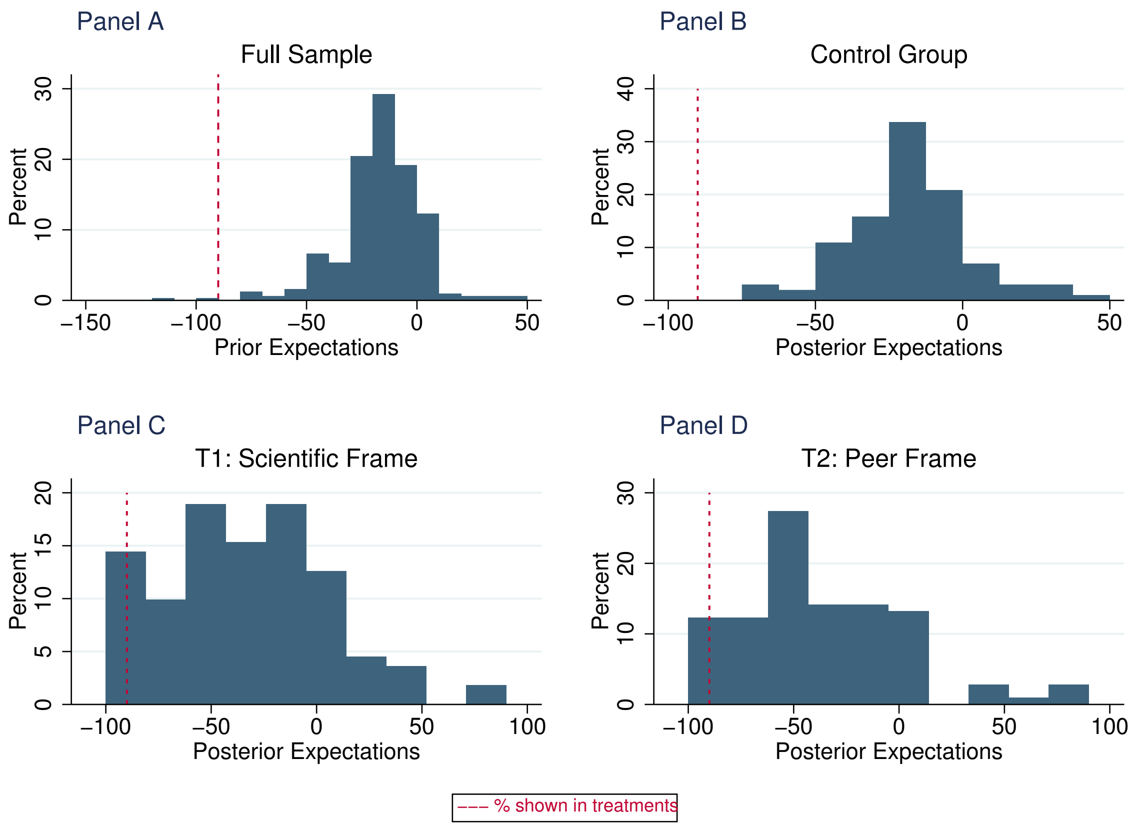
Appendix

A.1 Distribution of quantitative expectations

Figure 1: Distribution of quantitative expectations



A.2 t-tests by treatment groups

Table 1: Statistic tests for outcome variables

	Control vs. T1[1]	Control vs. T2[1]	Sign. Diff[2]
Prior expectations		**	*
Misperceptions		**	*
Posterior expectations	***	***	***
Updated expectations	***	***	***
Intentions			
WTA[‡]		*	

Notes: T1 vs. T2 not significantly different. [1]P-value of t-test between the two groups. [2]Based on Kruskal-Wallis test between the three groups. [‡]Responses were winsorized at the 95-percentile. Statistical significance: *p $<$ 0.10; **p $<$ 0.05; ***p $<$ 0.01.

A.3 t-tests by the updated qualitative expectations

Table 2: t-tests by the updated qualitative expectations

	Negative change vs. No change - positive	Negative change vs. No change - negative	Positive change vs. No change - negative	Positive change vs. No change - positive	No change - negative vs. No change - positive
Stocking rate			***	***	
Clover content	**		**		***
Posterior expectations		***	***	*	*
Updated expectations		**	***		
Intentions	**	***	***	***	***
WTA	**			**	

Notes: t-tests were not significantly different for Negative change vs. Positive change. Statistical significance: *p $<$ 0.10; **p $<$ 0.05; ***p $<$ 0.01.

A.4 Response type categories: Hand-coding

Table 3: Response type categories: Hand-coding

Broader category	Specific elements
Clover management issues	Difficult management grassland (e.g., Weeds, Difficult maintenance); Difficult management grazing (e.g., Difficult rotations); Difficult persistence; Difficulties associated with clover establishment (e.g., Difficulties with over-sowing or reseeding)
Animal health issues	Bloat (e.g., Bolted cows, Acidosis); Hungry cows; Other animal health issues (e.g., Urine issues, Fertility issues)
Output issues	Low profit; Insufficient grass cover (e.g., Low growth, Open swards, Spring issues); Seasonal production issues; Maintain production (e.g., Inconsistent dry matter); Lack effectiveness
Input issues	High costs (e.g., Lack own seeder); High labour (e.g., Time consuming, Lack time); Learning curve (e.g., Lack knowledge, Unknown fertilizer app. with clover); Lack information (e.g., Lack advisor, Lack plan)

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Broader category	Specific elements
Farm conditions issues	Soil fertility; Land type; Poaching; Leaching
Weather issues	Drought; Wet land; Flooding
Other issues	GHG overstated problem; Other personal issues (e.g., Different mindset, Confidence); Past negative experiences
Perceived benefits	Good for environment; Reduce chemical fertilizer (e.g., Reduce chemical N reliance, N reduction, N fixation, Substitute chemical fertilizer, Zero N); Reduce costs (e.g., Savings chemical fertilizer); Better production (e.g., Good quality silage, Better grazing)
Disagreement / Agreement	General (dis)agreement with the current recommendation of clover content
Intention	Stated intention to adopt the current recommendation of clover content
Disagreement / Agreement information	General (dis)agreement with information presented

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Broader category	Specific elements
No change – negative / positive opinion	No change indicated in posteriors, with a negative/positive opinion in priors
Other	Residual category
Invalid	Blank responses

A.5 Reasons for having low clover content

Table 4: Reasons for having low clover content

	Control group	Treatment 1	Treatment 2	Full sample
Difficult establishment	39	33	33	105
	39.39 %	30.00 %	31.43 %	33.44 %
It does not suit my farm system	24	14	13	51
	24.24 %	12.73 %	12.38 %	16.24 %
New process	15	15	19	49
	15.15 %	13.64 %	18.10 %	15.61 %
High labour	9	16	18	43
	9.09 %	14.55 %	17.14 %	13.69 %
Lack information	12	17	13	42
	12.12 %	15.45 %	12.38 %	13.38 %
Other	11	12	10	33
	11.11 %	10.91 %	9.52 %	10.51 %
I am not interested in implementing clover	6	10	7	23
	6.06 %	9.09 %	6.67 %	7.32 %
Bloat	4	3	6	13
	4.04 %	2.73 %	5.71 %	4.14 %
Observations	99	110	105	314

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	Control group	Treatment 1	Treatment 2	Full sample
Difficult management grassland	2	8	3	13
	2.02 %	7.27 %	2.86 %	4.14 %
Insufficient grass cover	4	4	2	10
	4.04 %	3.64 %	1.90 %	3.18 %
Difficult management grazing	2	1	2	5
	2.02 %	0.91 %	1.90 %	1.59 %
Difficult persistence	2	2	1	5
	2.02 %	1.82 %	0.95 %	1.59 %
Drought	2	2	1	5
	2.02 %	1.82 %	0.95 %	1.59 %
Soil fertility	1	0	3	4
	1.01 %	0.00 %	2.86 %	1.27 %
High costs	2	1	1	4
	2.02 %	0.91 %	0.95 %	1.27 %
Learning curve	1	2	1	4
	1.01 %	1.82 %	0.95 %	1.27 %
Observations	99	110	105	314

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	Control group	Treatment 1	Treatment 2	Full sample
Other animal	1	1	0	2
health issues	1.01 %	0.91 %	0.00 %	0.64 %
Past negative	0	2	0	2
experiences	0.00 %	1.82 %	0.00 %	0.64 %
Wet land	1	0	0	1
	1.01 %	0.00 %	0.00 %	0.32 %
Lack effectiveness	0	1	0	1
	0.00 %	0.91 %	0.00 %	0.32 %
Invalid	1	0	0	1
	1.01 %	0.00 %	0.00 %	0.32 %
Total	139	144	133	416
Observations	99	110	105	314

Notes: For each category, the first row has frequencies and the second row has column percentages.We could not reject the null hypothesis that both categorical variables are independent (p-value of Pearson's χ^2 test equals 0.59).

A.6 Response types in the open-text data: Prior Expectations

Table 5: Response types in the open-text data: Prior Expectations

	Control group	Treatment 1	Treatment 2	Full sample
Clover management issues	35	27	31	93
	34.65 %	24.32 %	29.25 %	29.25 %
Agreement	22	28	31	81
	21.78 %	25.23 %	29.25 %	25.47 %
Animal health issues	18	18	17	53
	17.82 %	16.22 %	16.04 %	16.67 %
Input issues	16	16	16	48
	15.84 %	14.41 %	15.09 %	15.09 %
Output issues	16	16	10	42
	15.84 %	14.41 %	9.43 %	13.21 %
Intention	19	11	7	37
	18.81 %	9.91 %	6.60 %	11.64 %
Other	1	17	11	29
	0.99 %	15.32 %	10.38 %	9.12 %
Disagreement	8	10	10	28
	7.92 %	9.01 %	9.43 %	8.81 %
Perceived benefits	7	8	10	25
	6.93 %	7.21 %	9.43 %	7.86 %
Farm conditions issues	6	8	7	21
	5.94 %	7.21 %	6.60 %	6.60 %
Weather issues	4	8	5	17
	3.96 %	7.21 %	4.72 %	5.35 %
Other issues	4	6	4	14
Observations:	101	111	106	318

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Table 5: Response types in the open-text data: Prior Expectations

	Control group	Treatment 1	Treatment 2	Full sample
	3.96 %	5.41 %	3.77 %	4.40 %
Invalid	1	1	2	4
	0.99 %	0.90 %	1.89 %	1.26 %
Total:	157	174	161	492
Observations:	101	111	106	318

Notes: For each category, the first row has frequencies and the second row has column percentages. We could not reject the null hypothesis that both categorical variables are independent (p-value of Pearson's χ^2 test equals 0.45).

A.7 Response types in the open-text data: Posterior Expectations

Table 6: Response types in the open-text data: Posterior Expectations

	Control group	**Treatment 1**	**Treatment 2**	**Full sample**
Clover management issues	28	18	19	65
	27.72 %	16.22 %	17.92 %	20.44 %
Perceived benefits	8	17	26	51
	7.92 %	15.32 %	24.53 %	16.04 %
Output issues	10	23	17	50
	9.90 %	20.72 %	16.04 %	15.72 %
Agreement	17	15	13	45
	16.83 %	13.51 %	12.26 %	14.15 %
Animal health issues	20	9	12	41
	19.80 %	8.11 %	11.32 %	12.89 %
Invalid	21	2	13	36
	20.79 %	1.80 %	12.26 %	11.32 %
Input issues	13	5	13	31
	12.87 %	4.50 %	12.26 %	9.75 %
Intention	12	9	6	27
Observations:	101	111	106	318

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Table 6: Response types in the open-text data: Posterior Expectations

	Control group	**Treatment 1**	**Treatment 2**	**Full sample**
	11.88 %	8.11 %	5.66 %	8.49 %
Farm conditions issues	3	7	17	27
	2.97 %	6.31 %	16.04 %	8.49 %
Disagreement	4	12	9	25
	3.96 %	10.81 %	8.49 %	7.86 %
Other	5	15	5	25
	4.95 %	13.51 %	4.72 %	7.86 %
Disagreement information	0	10	7	17
	0.00 %	9.01 %	6.60 %	5.35 %
Other issues	1	6	3	10
	0.99 %	5.41 %	2.83 %	3.14 %
Weather issues	2	1	3	6
	1.98 %	0.90 %	2.83 %	1.89 %
Agreement information	0	1	1	2
	0.00 %	0.90 %	0.94 %	0.63 %
Observations:	101	111	106	318

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Table 6: Response types in the open-text data: Posterior Expectations

	Control group	Treatment 1	Treatment 2	Full sample
No change – negative	1	0	1	2
opinion	0.99 %	0.00 %	0.94 %	0.63 %
No change – opinion	1	0	1	2
opinion	0.99 %	0.00 %	0.94 %	0.63 %
Total	146	150	166	462
Observations	101	111	106	318

Notes: For each category, the first row has frequencies and the second row has column percentages. We reject the null hypothesis that both categorical variables are independent (p-value of Pearson's χ^2 test equals 0.00).

A.8 Response types in the open-text data: Updated Expectations

Table 7: Response types in the open-text data: Updated Expectations

	Control group	Treatment 1	Treatment 2	Full sample
No change – negative	50	48	37	135
opinion	49.51%	43.24%	34.91%	42.45%
No change – positive	38	31	29	98
opinion	37.62%	27.93%	27.36%	30.82%
Positive change	8	17	21	46
	7.92%	15.32%	19.81%	14.47%
Negative change	5	13	16	34
	4.95%	11.71%	15.09%	10.69%
Other	0	1	2	3
	0.00%	0.90%	1.89%	0.94%
Invalid	0	1	1	2
	0.00%	0.90%	0.94%	0.63%
Observations	101	111	106	318

Notes: For each category, the first row has frequencies and the second row has relative frequencies. When excluding the residual category 'other' and 'invalid', we reject the null hypothesis that both categorical variables are independent (p-value of Pearson's χ^2 test equals 0.05).

A.9 ChatGPT message

The following message was used to ask ChatGPT to categorize the updated qualitative expectations:

"In my survey, participants have answered a same question twice. The question was: "The current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area. When you hear this recommendation, please let us know what comes to your mind?". I want to create a new variable called: the update in responses. The objective of this variable is to find if there was a change in opinions from the first response to the second response. For this, I have created five categories: 'Positive change in opinions', 'Negative change in opinions', 'No change but keeping a general negative opinion', 'No change but keeping a general positive opinion', and 'other' (residual category). Please, can you help me categorize responses according to these five categories? For subject: [Subject ID] , the first response was: [Prior expectations] ; the second response was: [Posterior expectations]. To what category does it correspond?"

Sometimes, ChatGPT had trouble categorizing those who had one response empty, or no change in responses. Then, two follow-up questions were displayed: "Please, just consider the first/second response", or "Which no change category: 'No change but keeping a general negative opinion', or 'No change but keeping a general positive opinion'?"

A.10 Steps for data cleaning of fraudulent responses

The following steps were used for data cleaning of fraudulent responses:

1. Discard recordings with duplicated answers in the open-ended questions: We first checked individual responses that were received the morning of the 30th of January 2023. Our qualitative measurement of expectations, using open-ended questions, is useful because their responses are most likely not duplicated across participants. Email addresses, and IP addresses, of those that had duplicated responses in the open-ended questions were verified. If identified as high risk of fraudulent, then they were dropped. We repeated this first step with the rest of entries, regardless of their recording date.

2. Observe individually the rest of responses received the morning of the 30th of January, with particular focus on email addresses, and IP addresses outside Ireland. If high fraudulent risk, responses were discarded.

3. Drop incomplete responses, with less than 80% of progress in the survey.

4. Drop recordings that viewed the information treatments for less than two seconds.

5. Examine all the recordings individually, again special focus on email addresses, and IP addresses outside Ireland. Again, if high fraudulent risk, responses were discarded.

A.11 OLS - 'naive' regression

Table 8: Effects of the updated expectations on intentions and WTA

	OLS - 'naive' regression			
	Intentions		**WTA**	
	(1)	(2)	(3)	(4)
Updated Expectations	0.06	0.06	0.66	0.55
	(0.05)	(0.05)	(0.40)	(0.40)
Control variables[1]	No	Yes	No	Yes
R^2	0.00	0.10	0.01	0.07
Observations	318	316	318	316

Notes: Robust standard errors are reported in parentheses. Statistical significance: *p < 0.10; **p < 0.05; ***p < 0.01. [1]Control variables included: herd size, fertilizer application, clover content, environmental attitudes, age, gender, knowledge transfer engagement, and education in agriculture.

A.12 Descriptive statistics by the updated qualitative expectations

Table 9: Descriptive statistics by the updated qualitative expectations

	No change - negative	**No change - positive**	**Positive change**	**Negative change**	**Full sample**[1]
Panel A: Control variables					
Farm size (ha)	77.89	80.96	73.83	90.81	79.66
	(41.08)	(54.25)	(53.50)	(61.80)	(49.77)
Herd size (# cows)	136.56	132.73	131.98	154.15	136.60
	(88.74)	(104.42)	(83.84)	(128.36)	(97.83)
Stocking rate (Farm size/Herd size)	1.76	1.66	2.09	1.70	1.77*
	(0.47)	(0.52)	(0.96)	(0.53)	(0.60)
Fertilizer application‡ (kg N/ha)	239.43	218.06	207.50	203.47	224.14
	(172.24)	(157.38)	(148.84)	(103.32)	(158.01)
Clover content (% weighted average)	5.19	7.29	6.80	5.20	6.08***
	(4.19)	(5.04)	(4.49)	(4.84)	(4.67)
Age = 1 if older than 46 (%)	53.33	47.96	43.48	44.12	49.20
Gender = 1 if male (%)	93.33	93.88	86.96	97.06	92.97
Knowledge transfer = 1 if involved (%)	80.74	78.57	73.91	82.35	79.23
Agricultural education = 1 if $\geq 3^{\text{rd}}$ level (%)	28.89	24.49	28.26	29.41	27.48
Panel B: Outcome variables					
Prior expectations (% change)	18.93	20.66	23.70	22.00	20.51
	(17.23)	(20.45)	(21.33)	(16.61)	(18.85)
Posterior expectations (% change)	23.41	31.44	43.93	41.26	30.88***
	(32.02)	(37.51)	(40.45)	(31.55)	(35.78)
Updated expectations (% change)	4.47	10.78	20.24	19.26	10.37***
	(31.15)	(35.09)	(35.11)	(29.08)	(33.24)
Intentions (% prob. of adoption)	39.96	73.34	58.80	59.41	55.29***
	(28.37)	(27.32)	(30.50)	(26.73)	(31.54)
WTA‡ (Savings in €/ha)	146.23	131.27	195.66	201.19	154.78*
	(194.42)	(146.98)	(220.00)	(212.94)	(188.19)
Observations:	135	98	46	34	313

Notes: Standard deviations are reported in parentheses. ‡Responses were winsorized at the 95-percentile. [1]Statistical significance based on Kruskal-Wallis test between the four groups: *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

A.13 Robustness Checks

We mitigate concerns on the issue of multiple hypothesis testing by applying Romano-Wolf multiple hypothesis correction (Clarke et al., 2020).

Table 10: Romano-Wolf adjusted p-values

	Stage I	
	Updated Expectations	
	(3)	(4)
T1: Scientific Frame	0.00	0.00
	[0.01]	[0.01]
T2: Peer Frame	0.00	0.00
	[0.01]	[0.01]
Control variables[1]	No	Yes
R^2	0.07	0.09
Observations	318	316

Notes: This table applies Romano-Wolf multiple hypothesis correction to columns (3) and (4) in table 3. Romano-Wolf p-values are reported in square brackets. [1]Control variables included: herd size, fertilizer application, clover content, environmental attitudes, age, gender, knowledge transfer engagement, and education in agriculture.

Table 11: Romano-Wolf adjusted p-values

	2SLS			
	Intentions		WTA	
	(1)	(2)	(3)	(4)
Updated Expectations ($\Delta\hat{Exp}$)	0.26	0.25	0.12	0.22
	[0.27]	[0.27]	[0.10]	[0.22]
Control variables[1]	No	Yes	No	Yes
Observations	318	316	318	316

Notes: This table applies Romano-Wolf multiple hypothesis correction to the regressions in Panel A of table 4. Romano-Wolf p-values are reported in square brackets. [1]Control variables included: herd size, fertilizer application, clover content, environmental attitudes, age, gender, knowledge transfer engagement, and education in agriculture.

Table 12: Romano-Wolf adjusted p-values

	OLS Qualitative updated expectations			
	No change - negative	**No change - positive**	**Positive change**	**Negative change**
	(1)	(2)	(3)	(4)
T1:Scientific Frame	0.30	0.16	0.08	0.07
	[0.33]	[0.14]	[0.12]	[0.10]
T2: Peer Frame	0.05	0.08	0.01	0.02
	[0.04]	[0.11]	[0.01]	[0.02]
Control variables[1]	Yes	Yes	Yes	Yes
R^2	0.07	0.06	0.04	0.04
Observations	316	316	316	316

Notes: This table applies Romano-Wolf multiple hypothesis correction to the regressions in Table 5. Romano-Wolf p-values are reported in square brackets. [1]Control variables included: herd size, fertilizer application, clover content, environmental attitudes, age, gender, knowledge transfer engagement, and education in agriculture.

A.14 How did you come across this survey?

Table 13: How did you come across this survey?

	Full sample
Farm advisors	124
	39.24 %
Discussion groups	122
	38.61 %
Other	52
	16.46 %
Farming press	31
	9.81 %
Twitter	9
	2.85 %
Total	338
Observations	316

Notes: For each category, the first row has frequencies and the second row has column percentages.

A.15 Are you a member of a discussion group?

Table 14: Are you a member of a discussion group?

	Full sample
Yes, in a non-private group (e.g., Teagasc run group)	232
	74.84 %
Yes, in a private group	57
	18.39 %
No	40
	12.90 %
Total	329
Observations	310

Notes: For each category, the first row has frequencies and the second row has column percentages.

A.16 What Signpost initiatives have you used or participated in?

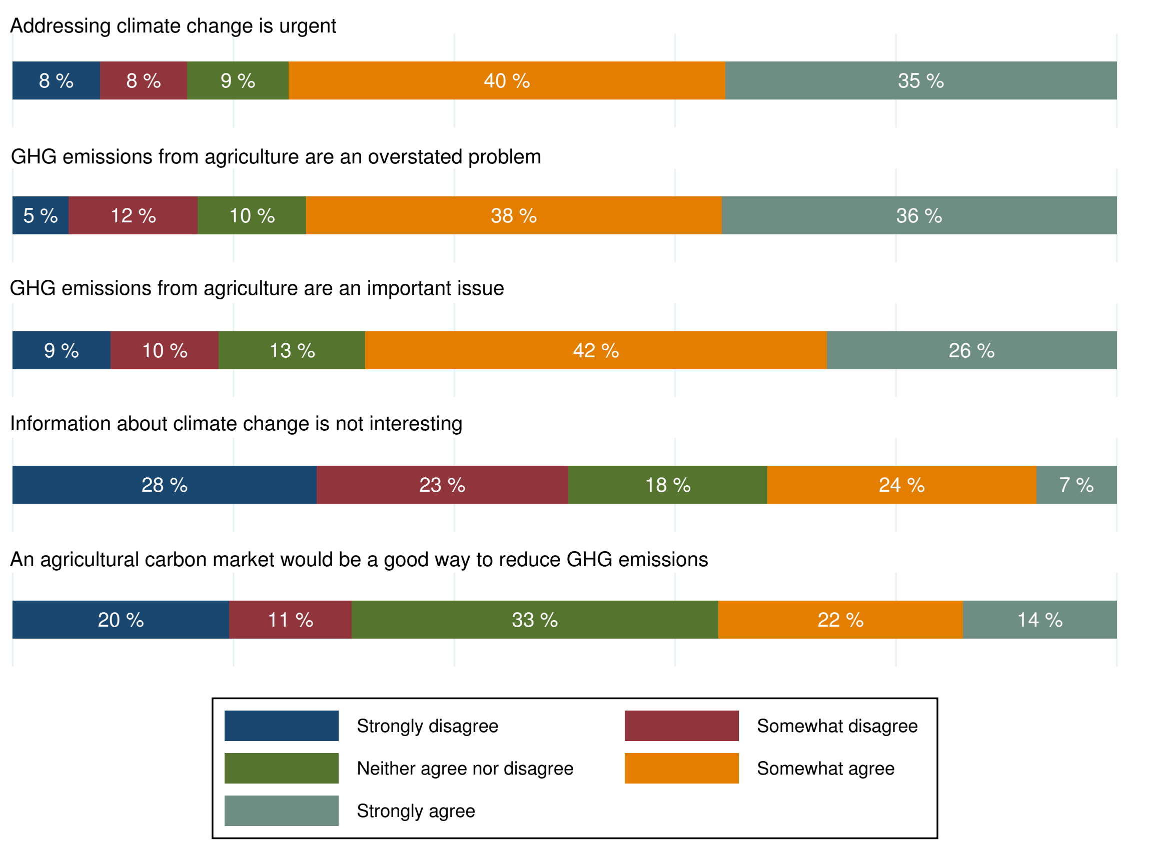
Table 15: What Signpost initiatives have you used or participated?

	Full sample
Read newsletters	177
	65.31 %
Visited Signpost demonstration farms	157
	57.93 %
Participated in online seminars	78
	28.78 %
None	20
	7.38 %
Other	4
	1.48 %
Total	436
Observations	271

Notes: For each category, the first row has frequencies and the second row has column percentages.

A.17 Environmental attitudes

Figure 2: Environmental attitudes



A.18 Descriptive statistics of other variables

Table 16: Descriptive statistics of other variables

	Control group	**Treatment 1**	**Treatment 2**	**Full sample**
Time (seconds on treatment)	20.30	28.70	30.47	26.62
	(13.35)	(16.80)	(16.54)	(16.25)
Age† (%)				
18 - 25	7.07	4.50	3.85	5.10
26 - 35	12.12	23.42	28.85	21.66
36 - 45	26.26	22.52	22.12	23.57
46 - 55	30.30	28.83	27.88	28.98
56 - 65	21.21	19.82	15.38	18.79
65+	3.03	0.90	1.92	1.91
Total	100.00	100.00	100.00	100.00
Gender† (%)				
Male	93.94	93.69	94.23	93.95
Female	6.06	4.50	4.81	5.10
Non-binary / third gender	0.00	0.90	0.96	0.64
Prefer not to say	0.00	0.90	0.00	0.32
Total	100.00	100.00	100.00	100.00
Signpost awareness† (%)				
No	11.00	18.02	12.50	13.97
Yes	89.00	81.98	87.50	86.03
Total	100.00	100.00	100.00	100.00
Location† (%)				
Observations:	101 (†99)	111	106 (†104)	318 (†314)

Continued on next page...

...continued from previous page

Table 16: Descriptive statistics of other variables

	Control group	Treatment 1	Treatment 2	Full sample
Carlow	3.03	0.90	0.96	1.59
Cavan	6.06	0.90	3.85	3.50
Clare	2.02	3.60	4.81	3.50
Cork	17.17	20.72	21.15	19.75
Donegal	1.01	0.90	4.81	2.23
Dublin	0.00	0.90	0.00	0.32
Galway	2.02	1.80	3.85	2.55
Kerry	16.16	13.51	13.46	14.33
Kildare	2.02	1.80	1.92	1.91
Kilkenny	4.04	3.60	4.81	4.14
Laois	2.02	7.21	0.96	3.50
Limerick	4.04	7.21	7.69	6.37
Longford	1.01	0.90	1.92	1.27
Louth	2.02	1.80	0.96	1.59
Mayo	2.02	3.60	0.96	2.23
Meath	8.08	2.70	1.92	4.14
Monaghan	1.01	0.90	2.88	1.59
Offaly	5.05	4.50	4.81	4.78
Roscommon	0.00	0.90	0.96	0.64
Sligo	1.01	0.00	0.00	0.32
Tipperary	15.15	9.91	9.62	11.46
Waterford	1.01	1.80	1.92	1.59
Westmeath	1.01	1.80	0.00	0.96
Observations:	101 (†99)	111	106 (†104)	318 (†314)

Continued on next page...

...continued from previous page

Table 16: Descriptive statistics of other variables

	Control group	**Treatment 1**	**Treatment 2**	**Full sample**
Wexford	1.01	5.41	5.77	4.14
Wicklow	2.02	2.70	0.00	1.59
Total	100.00	100.00	100.00	100.00
Highest level of				
general education† (%)				
Primary School	1.01	0.00	0.96	0.64
Secondary School (inter cert)	13.13	9.91	11.54	11.46
Secondary School (leaving cert)	27.27	22.52	16.35	21.97
Third level	51.52	51.35	61.54	54.78
Postgraduate	5.05	11.71	7.69	8.28
Other:	2.02	4.50	1.92	2.87
Total	100.00	100.00	100.00	100.00
Highest level of				
agr. education† (%)				
100 hours of training	11.36	10.89	9.57	10.60
Cert in farming	28.41	27.72	31.91	29.33
1-year agricultural college	26.14	19.80	21.28	22.26
Farm apprenticeship	6.82	5.94	6.38	6.36
Third level in agriculture	25.00	34.65	28.72	29.68
Other:	2.27	0.99	2.13	1.77
Total	100.00	100.00	100.00	100.00
Observations:	101 (†99)	111	106 (†104)	318 (†314)

Continued on next page...

...continued from previous page

Table 16: Descriptive statistics of other variables

	Control group	Treatment 1	Treatment 2	Full sample
Inattention† = 1 if any sign of inattention (%)	21.78	25.23	27.36	24.84
Consistency = 1 if unchanged quant. & qual. exp. (%)	63.37	20.72	13.21	31.76
Observations:	101 (†99)	111	106 (†104)	318 (†314)

Notes: Standard deviations are reported in parentheses. Means across groups are not significantly different (t-tests and Kruskal-Wallis tests were made). [1]Cronbach's alpha: 0.61. †Indicates a different number of observations. ‡Responses were winsorized at the 95-percentile to reduce the effect of outliers.

A.19 Full survey

Start of Block: Introduction

Views and Opinions on Farm Practices

Many thanks for participating in this study. Your opinion is very important to us.

Please note, you have to be a **dairy farmer** in the Republic of Ireland to participate. Please do NOT complete this survey if you are not a dairy farmer.

The aim of this study is to understand farmers' opinions on farm management practices, specifically on growing grass-clover swards.

This study is conducted by the [REDACTED] and [REDACTED].

The survey should take you around **10 minutes** to complete.

At the end of the survey, you have the opportunity to participate in a draw for thirty **€50** One4All vouchers.

Please be assured that your information will be treated **anonymously** and strictly **confidential**.

Page Break

Consent

Before you begin with the survey, please read the following text and indicate your consent below.

Your participation is entirely voluntary and you are free to exit the survey at any time. You have to be a dairy farmer in the Republic of Ireland, and at least 18 years of age to participate in this study. By participating, you are agreeing that the information collected will be used for research publications and other communication materials.

If you want more information or have a complaint, you can contact us at [REDACTED], or you can contact an independent person at [REDACTED].

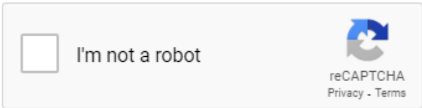
[Q1] **I confirm that I am a dairy farmer in the Republic of Ireland, at least 18 years of age, and I consent with the information provided above.**

◯ Yes

◯ No

Skip to: End of Survey if: [Q1] = No

[Captcha] Are you a robot?



[Q2] How did you come across this survey?

◯ Farming press

◯ Discussion groups

◯ Farm advisors

◯ Twitter

◯ Other: ____

End of Block: Introduction

Start of Block: Farm Characteristics

First, please tell us about your farm.

[Q3] How many acres or hectares did you farm in 2022?

◯ Acres: ____

◯ Hectares: ____

Page Break

[Q4] How many cows did you milk in 2022?

____

End of Block: Farm Characteristics

Start of Block: Fertilizer Usage

[Q5] In 2022, how much **chemical nitrogen fertilizer** did you apply on your farm? *Please choose your preferred measure and include a value in the associated box. If you do not know the exact figure, please provide your best guess.*

○ I know the value in **kg/ha**: ____

○ I know the value in **kg** (total farm): ____

○ I'm unsure but my best guess in **kg/ha** is: ___________________________________

○ I'm unsure but my best guess in **kg** (total farm) is: ____________________________

○ I know the value in **another measure** *(please state value and measure)*: __________

○ I'm unsure but my best guess in **another measure** is *(please state value and measure)*: ______________________________________

Page Break

[Q6] What percentage of the grassland area on your farm has been reseeded in the last 3 years?

________________ %

End of Block: Fertilizer Usage

Start of Block: Clover Content

Next, we would like to know how much clover you have on your farm.

[Q7] **In 2022, what percentage of the grassland area on your farm had the following clover content?**
(Answers must add to 100%. For example, 80% of the grassland area on your farm had 0% clover content, and 20% had 5-9% clover content.)

	% of the grassland area:
0% clover	☐ %
1-4% clover	☐ %
5-9% clover	☐ %
10-14% clover	☐ %
15-19% clover	☐ %
20% clover or more	☐ %
Total	☐ %

Page Break

4

Display this Question:

If [Q7] = [20% clover content or more] ≠ 100

[Q8] Please let us know why you don't have more clover.
(Please tick all that apply)

- ☐ I am not interested in implementing clover
- ☐ It does not suit my farm system
- ☐ Difficult to establish
- ☐ Too labour intensive
- ☐ I don't have enough information about clover
- ☐ Other: ____

End of Block: Clover Content

Start of Block: Prior Expectations

[Q9] **The current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.**

When you hear this recommendation, please let us know **what comes to your mind?**

Use the text box below and write as much as you feel like. We are interested in hearing your own opinion. There is no right or wrong answer.

____

____

____

____

Page Break

Display this Question:

If [Q7] = [20% clover content or more] ≠ 100

[Q10] **The current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.**

Imagine you had implemented this recommendation on your farm. How much do you think your application of chemical nitrogen fertilizer would change?

Please provide your best guess as a percentage change of fertilizer application.

◯ Increase by: ____ %

◯ Decrease by: ____ %

◯ No change in fertilizer application

Display this Question:

If [Q7] = [20% clover content or more] = 100

[Q11] **The current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.**

Imagine you maintained this recommendation. How much do you think your application of chemical nitrogen fertilizer would change?

Please provide your best guess as a percentage change of fertilizer application.

◯ Increase by: ____ %

◯ Decrease by: ____ %

◯ No change in fertilizer application

End of Block: Prior Expectations

Start of Block: Treatment: Scientific Frame

Display this Question:

If

Scientific frame: Is randomly assigned

[Timer 1]

[Q12] **Please read the following information carefully, as it is important for the rest of the survey:**

Scientific studies show that by establishing at least 20% clover content in all of a farm's grassland area, **it is possible to reduce chemical nitrogen fertilizer by 90%**.

Based on those scientific studies, for the average dairy farmer, this would mean that chemical nitrogen fertilizer application can be reduced from **166.6 kg N/ha to 16.6 kg N/ha**.

(Figures are based on 2021 average chemical nitrogen fertilizer application rates of dairy farmers in Ireland)

Page Break

Display this Question:

If [Q7] = [20% clover content or more] ≠ 100

[Q13] **Based on this information**, we would like to give you the opportunity to re-state your previous guess.

As mentioned, the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.

Again, imagine you had implemented this recommendation on your farm. How much do you think your application of chemical nitrogen fertilizer would change?

Please provide your best guess as a percentage change.

◯ Increase by: ____ %

◯ Decrease by: ____ %

◯ No change in fertilizer application

Display this Question:

If [Q7] = [20% clover content or more] = 100

[Q14] **Based on this information**, we would like to give you the opportunity to re-state your previous guess.

As mentioned, the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.

Again, imagine you maintained this recommendation. How much do you think your application of chemical nitrogen fertilizer would change?

Please provide your best guess as a percentage change.

◯ Increase by: ____ %

◯ Decrease by: ____ %

◯ No change in fertilizer application

Page Break

[Timer 2]

[Q15] Remember that **scientific studies** show that by establishing at least 20% clover content in all of a farm's grassland area, **it is possible to reduce chemical nitrogen fertilizer by 90%**.

Based on those scientific studies, for the average dairy farmer, this would mean that chemical nitrogen fertilizer application can be reduced from **166.6 kg N/ha to 16.6 kg N/ha**.

(Figures are based on 2021 average chemical nitrogen fertilizer application rates of dairy farmers in Ireland)

[Q16] **Please consider again that the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.**

In light of this information, now when you hear this recommendation **what comes to your mind?**

Use the text box below and write as much as you feel like. We are interested in hearing your own opinion. There is no right or wrong answer.

____
____
____
____

End of Block: Treatment: Scientific Frame

Start of Block: Treatment: Peer Frame

Display this Question:

If

Peer frame: Is randomly assigned

[Timer 3]

[Q17] **Please read the following information carefully, as it is important for the rest of the survey:**

Scientific studies show that by establishing at least 20% clover content in all of a farm's grassland area it is possible to reduce chemical nitrogen fertilizer by 90%. Some **dairy farmers** who have established this clover content on their farms were able to reduce chemical nitrogen fertilizer application.

Based on the scientific studies, for the average dairy farmer, this would mean that chemical nitrogen fertilizer application can be reduced from **166.6 kg N/ha to 16.6 kg N/ha**.

(Figures are based on 2021 average chemical nitrogen fertilizer application rates of dairy farmers in Ireland)

Page Break

Display this Question:

If [Q7] = [20% clover content or more] ≠ 100

[Q18] **Based on this information**, we would like to give you the opportunity to re-state your previous guess.

As mentioned, the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.

Again, imagine you had implemented this recommendation on your farm. How much do you think your application of chemical nitrogen fertilizer would change?

Please provide your best guess as a percentage change.

○ Increase by: ____ %

○ Decrease by: ____ %

○ No change in fertilizer application

Display this Question:

If [Q7] = [20% clover content or more] = 100

[Q19] **Based on this information**, we would like to give you the opportunity to re-state your previous guess.

As mentioned, the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.

Again, imagine you maintained this recommendation. How much do you think your application of chemical nitrogen fertilizer would change?

Please provide your best guess as a percentage change.

○ Increase by: ____ %

○ Decrease by: ____ %

○ Stay the same

Page Break

[Timer 4]

[Q20] Remember that **scientific studies** show that by establishing at least 20% clover content in all of a farm's grassland area **it is possible to reduce chemical nitrogen fertilizer by 90%**. Some **dairy farmers** who have established this clover content on their farms were able to reduce chemical nitrogen fertilizer application.

Based on the scientific studies, for the average dairy farmer, this would mean that chemical nitrogen fertilizer application can be reduced from **166.6 kg N/ha to 16.6 kg N/ha**.

(Figures are based on 2021 average chemical nitrogen fertilizer application rates of dairy farmers in Ireland)

[Q21] **Please consider again that the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.**

In light of this information, now when you hear this recommendation **what comes to your mind?**

Use the text box below and write as much as you feel like. We are interested in hearing your own opinion. There is no right or wrong answer.

____

____

____

____

End of Block: Treatment: Peer Frame

Start of Block: Control Group

Display this Block:

If

Control group: Is randomly assigned

[Timer 5]

[Q22] **Did you know that…?**

Clover can have more than four leaves. The highest ever recorded is a 56-leaf clover found by farmer Shigeo Obara in Japan. He was awarded the Guinness World Record in 2009. While some say that 4-leaf clovers symbolize good luck, and 5-leaf clovers symbolize wealth, it is unclear what a 56-leaf clover symbolizes.

Page Break

Display this Question:

If [Q7] = [20% clover content or more] ≠ 100

[Q23] We want to give you the opportunity to reassess your answers to some of the previous questions. This opportunity is given to all survey participants, regardless of their responses.

As mentioned, the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.

Again, imagine you had implemented this recommendation on your farm. How much do you think your application of chemical nitrogen fertilizer would change?

Please provide your best guess as a percentage change.

- ○ Increase by: ____ %
- ○ Decrease by: ____ %
- ○ No change in fertilizer application

Display this Question:

If [Q7] = [20% clover content or more] = 100

[Q24] We want to give you the opportunity to reassess your answers to some of the previous questions. This opportunity is given to all survey participants, regardless of their responses.

As mentioned, the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.

Again, imagine you maintained this recommendation. How much do you think your application of chemical nitrogen fertilizer would change?

Please provide your best guess as a percentage change.

◯ Increase by: ____ %

◯ Decrease by: ____ %

◯ No change in fertilizer application

Page Break

[Q25] We also want to give you the opportunity to express your opinion again, as you have spent some time thinking about clover during the survey.

Remember that the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.

Please let us know, now when you hear this recommendation **what comes to your mind?**

Use the text box below and write as much as you feel like. We are interested in hearing your own opinion. There is no right or wrong answer.

____

____

____

____

End of Block: Control Group

Start of Block: Intention to Adopt

Display this Question:

If [Q7] = [20% clover content or more] ≠ 100

[Q26] What is the **probability** that within the next five years **you will establish at least 20% clover content** in all of your farm's grassland area?

	0 10 20 30 40 50 60 70 80 90 100
%	

Display this Question:

If [Q7] = [20% clover content or more] = 100

[Q27] What is the **probability** that within the next five years **you will maintain at least 20% clover content** in all of your farm's grassland area?

	0 10 20 30 40 50 60 70 80 90 100
%	

End of Block: Intention to Adopt

Start of Block: WTA

Display this Question:

If [Q7] = [20% clover content or more] ≠ 100

[Q28] One last time, please, recall the current recommendation for dairy farmers is to establish at least 20% clover content in all of their grassland area.

How much annual chemical nitrogen fertilizer savings would definitely motivate you to establish clover at the recommended level?

- ◯ €/ha: ____
- ◯ € (total farm): ____
- ◯ Regardless of savings, I would not establish clover at the recommended level

Display this Question:

If [Q7] = [20% clover content or more] = 100

[Q29] One last time, please, recall the current recommendation for dairy farmers is to establish at least 20% clover content in all their grassland area.

How much annual chemical nitrogen fertilizer savings would definitely motivate you to maintain clover at the recommended level?

○ €/ha: ____

○ € (total farm): ____

○ Regardless of savings, I would not maintain clover at the recommended level

End of Block: WTA

Start of Block: Environmental Attitudes

[Q30] **Please express how strongly you agree or disagree with each of the following statements**:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Addressing climate change is urgent	○	○	○	○	○
GHG emissions from agriculture are an overstated problem	○	○	○	○	○
GHG emissions from agriculture are an important issue	○	○	○	○	○
Information about climate change is not interesting	○	○	○	○	○
An agricultural carbon market would be a good way to reduce GHG emissions	○	○	○	○	○

End of Block: Environmental Attitudes

Start of Block: Advisory Service Use and Socio-economic Characteristics

You are nearly at the end of the survey. We just need a little bit more information about you.

[Q31] Do you make grassland management decisions on your farm?

○ No

○ Yes

[Q32] Are you a member of a discussion group?
(Please tick all that apply)

○ No

○ Yes, in a private group

○ Yes, in a non-private group (e.g. Teagasc run group)

[Q33] Are you aware of the Teagasc Signpost Programme?

○ No

○ Yes

Page Break

Display this Question:

If [Q33] = Yes

[Q34] What Signpost initiatives have you used or participated?
(Please tick all that apply)

- ○ Read newsletters
- ○ Participated in online seminars
- ○ Visited Signpost demonstration farms
- ○ None
- ○ Other *(please specify)*: ________________________________

Display this Question:

If [Q33] = Yes

[Q35] Are you a member of the Signpost Programme?

- ○ No
- ○ Yes

Page Break

[Q36] What is your age category?

- ◯ 18 - 25
- ◯ 26 - 35
- ◯ 36 - 45
- ◯ 46 - 55
- ◯ 56 - 65
- ◯ 65+

[Q37] What is your gender?

- ◯ Male
- ◯ Female
- ◯ Non-binary / third gender
- ◯ Prefer not to say

[Q38] In what county is your farm located?

▼ Carlow (1) ... Wicklow (26)

Page Break

[Q39] Do you have an off-farm job?

- ◯ No
- ◯ Yes

[Q40] What is your highest completed level of education?

◯ Primary School

◯ Secondary School (inter cert)

◯ Secondary School (leaving cert)

◯ Third level

◯ Postgraduate

◯ Other: ____

[Q41] Do you have any formal education/training in agriculture?

◯ No

◯ Yes

Page Break

Display this Question:

If [Q40] = Yes

[Q42] What is your highest level of education completed in agriculture?

◯ 100 hours of training

◯ Cert in farming

◯ 1-year agricultural college

◯ Farm apprenticeship

◯ Third level in agriculture

◯ Other: ____

End of Block: Advisory Service Use and Socio-economic Characteristics

Start of Block: Voucher

[Q43] Please enter your email address below if you would like to be included in the draw for a voucher. By providing your email address you consent that your email will be shared with the company that provides the gift cards.

____

Page Break

[Q44] Do you agree to be contacted to participate in any surveys that are conducted by the researchers of this study in the future?

Please be assured we will not use your email address for anything else and will not share your email with anyone else.

○ Yes

○ No

Page Break

Display This Question:

If [Q43] text response is empty

And [Q44] = Yes

[Q45] Please enter your email address:

____

End of Block: Voucher

End of Survey