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Factors influencing dairy farmers' adoption of best management grazing practices

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Abstract

Understanding of farmers' influences relating to the adoption of innovations is imperative for the Irish dairy sector to improve efficiencies and productivity. There is a particular need for a better appreciation of how farmers' grassland management practices are shaped. The Spring Rotation Planner (SRP) is a management tool that divides the area of a farm into weekly portions and takes the estimation out of planning the first grazing rotation. It offers a cost-saving alternative on many dairy farms, which could contribute to strengthening the competitiveness of the sector. Adoption rates of the SRP amongst farmers have been low despite extensive promotion of its advantages. This study therefore aims to use psychological constructs to analyse factors that affect the adoption of the SRP by commercial dairy farmers in Ireland. Dairy farmers (n=256) were surveyed from different regions within the country. Principal Component Analysis was used to empirically confirm the hypothesised Theory of Planned Behaviour (TPB) beliefs. Cluster analysis was thereafter employed as classification criteria to cluster respondents into types. The TPB was subsequently applied to explain intention to implement the SRP. Two clusters of farmers were elicited; low and high adopters of the SRP. Low-Adopters of the SRP were characterised by their high sense of resource constraint. It is recommended that carefully planned communication, targeted at the different farmer types, can help encourage uptake of the SRP.

1. Introduction

Food production is forecasted to expand greatly in the coming decades due to a rising global population (Godfray et al., 2010). Action is therefore required throughout the food system to meet the challenges of increasing the provision of food while simultaneously lowering environmental impacts associated with production. As the impact of food production on the environment is often determined by agricultural practices it is therefore important that farmers adopt practices that increase productivity, which in turn can reduce environmental damage (Hyland et al., 2016a). Improved grassland management is an innovation that is expected to increase production and profits while reducing damage to the environment (Borges et al., 2014). Practices such as effective grassland management may consequently allow the dairy sector achieve the goal of sustainable intensification; i.e. increasing output without adverse environmental impacts and without the cultivation of more land (Garnett and Godfray, 2012; Smith, 2012).

In many regions of Western Europe grass is the primary dietary constituent for dairy production systems due to favourable temperate climatic conditions. Ireland presents characteristics that are applicable to many European dairy farmers of similar climatic conditions. The topography of the country varies considerably, encapsulating an array of challenges and environments faced by dairy farmers in temperate regions. Irish dairy cattle are fed predominantly on grazed grass with grass silage complimented with some concentrate fed during winter; sometimes high levels of concentrates are used in the finishing period (O'Mara, 2012). However, Ireland has a competitive advantage over many European countries as it has the potential to grow grass forage over a long growing season. Consequently, 54% of the lifetime weight gain of cattle is typically derived from grazed grass and 24% from grass silage (O'Donovan et al., 2011).

The dairy sector represents an important agricultural sector in Ireland (Hennessy et al., 2013). The removal of EU milk quotas has offered many Irish dairy farmers the freedom to expand which requires increased focus on grass growth and utilisation at farm level. Indeed, dairy is considered the most profitable Irish farming sector with average farming incomes of €51,809 with 23% of overall incomes derived from direct payments (Teagasc, 2018). The dairy sector is nevertheless

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expected to increase output as part of the most recent national agriculture and food strategy “Food Wise 2025” (DAFM, 2016). The strategy outlines key actions necessary to ensure the agri-food sector maximises its contribution to economic growth and exports in an environmentally sustainable manner over a ten year period. Increasing grass utilisation by 2t/ha is one of the key actions outlined for Food Wise 2025 which could assist the dairy industry increase its output (DAFM, 2016).

Taube et al. (2014) and Baumont et al. (2014) have suggested that general improvements in pasture production efficiency can be achieved by increasing pasture utilization and placing less importance on external supplementary feed and fertilizer inputs. In an Irish context it has been shown that significant cost reductions can be achieved by extending the grazing season (Läpple et al., 2012). The profitability of Irish dairy farming is consequently underpinned by levels of grass utilisation (O’Donovan et al., 2011). However, on-farm grass utilisation amongst Irish farmers is low, with significant potential for expansion and increased efficiency through adoption of grassland-management technologies (Creighton et al., 2011). To maintain competitive globally it is imperative that Ireland fully exploits its climatic advantages and maximizes the level of grass utilization on dairy farms.

The underlying psychological constructs which affect farmers’ behaviour are often overlooked when evaluating the adoption of best management practices. When faced with technology that involves monetary, management, and social impacts, farmers may be uncertain about whether to adopt if these factors are in conflict (Kim et al., 2008). Whilst many studies have focused on farmer’s adoption of new and novel innovations (Cavallo et al., 2015; Hennessy et al., 2016; Long et al., 2016), it is also important to understand the reasons why adoption rates of more established technologies have not been higher. The Spring Rotation Planner (SRP) is a management tool that offers a cost-saving alternative on many Irish dairy farms, which could con- tribute to strengthening the competitiveness of the Irish dairy sector. It is used to divide the farm up into weekly portions and can help take the guess work out of planning the first grazing rotation. It is a simple but effective tool that ensures that sufficient grass is grazed early and it is easy to implement. Despite extensive promotion of the advantages of implementing the SRP adoption rates amongst farmers have been low. This paper therefore aims to use psychological constructs to analyse factors that affect the adoption of the SRP by commercial dairy farmers in Ireland. The study aims to determine homogenous farmer groups based on their respective perceptions of the SRP and to evaluate how this affects behaviour. In doing so, the study contributes to the branch of the wider technology adoption literature. An improved under- standing of how and why farmers make decisions can contribute to the design of effective advisory, promotion and policy interventions (Garforth, 2015).

1.1. *The Spring Rotation Planner*

The SRP is a grazing management tool that divides a farm into weekly grazing portions during spring. It is easy to implement and in- expensive; a strip wire is all that is required to allocate grazing. Milk production in Ireland is grass based, with calving date targeted to coincide with the start of grass growth. During the spring period grass growth is less than demand which transpires in a gradual decrease in overall farm cover. Therefore the SRP allocates the optimum quantity of pasture at these critical times in the grazing calendar when growth rates are typically lower than demand.

The SRP allocates a set area per day (or per week) from when the cows calve in early February to the ‘magic date’ in early April; the time when demand and supply are equivalent. Using a SRP to manage grass consequently allocates good quality grazed grass until the ‘magic day’; when grass growth meets demand. The planner was initially developed in New Zealand but differs in an Irish context due to slower spring- growth rates. Therefore, seven to ten days are added to the predicted ‘magic day’ when using the planner in Ireland.

Together with weekly measurement of average farm cover the SRP enables sufficient grass until the end of the first rotation. The SRP ensures sufficient grass is grazed early enough to allow time for regrowth for the second rotation and that a sorted distribution of grass yields is created, providing a continuous grass supply during the second rotation (Teagasc, 2016).

The main objectives of the plan are (Teagasc, 2017):

- For cows to graze as soon as possible post-calving. This is because feed allowance increases progressively from calving until the breeding season.

- To graze 30% of the farm area during February to stimulate regrowth for the second rotation (between April 1st and 10th).
- To have 60% of the farm area grazed by mid-March, and to prolong the remaining 40% until early April (later if growth rates are below normal).

The use of the SRP therefore guarantees control of feed supply at a critical period by reducing the area offered to the herd which would negatively affect pasture growth (Macdonald et al., 2010). The SRP initially begins on a slow rotation where 40% of the farm is initially grazed. Thereafter, the remaining 60% of the farm is grazed later in the spring. The daily grazing area is related to the rotation length, e.g. 1/60 is a 60-day rotation. For instance, on a 30 ha milking platform the rotation is calculated by 30 ha/60 days, which equates to 0.5 ha/day.

Farms which complete the first grazing rotation in advance of early April produce substantially more grass than farms which finish the first rotation thereafter. O'Donovan et al. (2015) depicted a 20% increase (1320 kg DM/ha compared to 1030 kg DM/ha) in grass production by advancing the finish date of the first rotation. Financial benefits are also associated with including grazed grass in the diet of spring calving dairy cows in early lactation. Through higher animal performance and lower feed costs early grazing can increase profitability by €2.70/cow/day. Other Irish studies have shown that efficiency and production focused farmers are more likely to adopt the SRP (Kelly et al., 2015; McKillop et al., 2018). However, this study aims to assert the psychological reasons for the adoption and non-adoption of the technology.

1.2. *Theoretical background: The Theory of Planned Behaviour*

This study attempts to explain the rates of grassland management technologies adoption using the Theory of Planner Behaviour (TPB) (Ajzen, 1991) as its conceptual framework. The main construct of the theory is that human behaviour can be explained through intention to behave in a particular way. Intention in its turn is the outcome of individual attitudes and beliefs, which are divided into three categories: personal, normative and control. Personal beliefs relate to an individual's perception of the outcomes of a specific behaviour, normative belief are related to the perceived social pressure to perform a behaviour and control beliefs are associated with the individuals perception of how easy or difficult it is to perform the behaviour (Fig. 1). Therefore, adoption of a grassland management tool is directly related to a farmer's intention to adopt it, which in turn, is based on the farmers' beliefs about the grassland management tool.

The TPB has been used in agricultural research to explain the pro- cesses of farmers' decision making (de Lauwere et al., 2012; Mattison and Norris, 2007). Using the three central constructs it is possible to identify how farmers evaluate the use of the SRP (attitude),to explore the role of perceived social pressure upon farmers to use a SRP (subjective norm), and to identify the farmers' perceptions about their capacity to use this innovation (perceived behavioural control). The TPB is based on aggregating attitude (A), social norms (SN), and perceived behavioural control (PBC) beliefs and can be depicted in a model to explain behavioural intention (BI) in Eq. (1). In the TPB model, β re- presents the empirically determined weights that estimate each aggregated belief and ε is defined as an error term:

$$BI = \beta_1 A + \beta_2 SN + \beta_3 PBC + \varepsilon \qquad (1)$$

2. **Methods**

2.1. *Questionnaire design and distribution*

Dairy farmers (n=256) were surveyed from each of the 12 advisory regions within Ireland and the farmers were all Teagasc clients. Teagasc is a national body providing integrated research, advisory and training services to the agriculture and food industry and rural communities in Ireland. Whilst not nationally representative of dairy farming in Ireland the research does give an indication of this system of farming in particular regions and the use of a SRP.

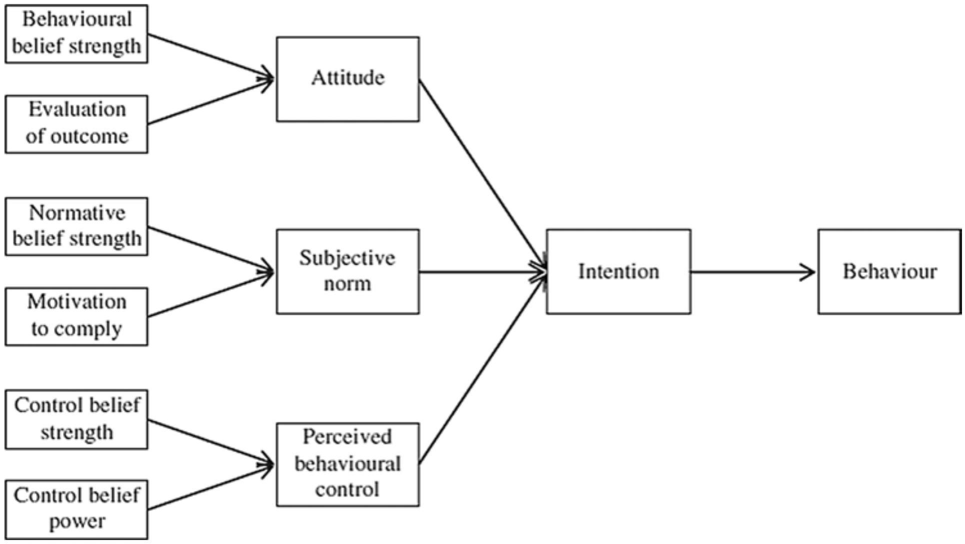

Fig. 1. Conceptual framework of the theory of planned behaviour.

The sample is representative of Teagasc dairy farmer clients.

A structured survey was designed using the TPB and included other socio-demographic variables. The survey was conducted over the tele- phone from May to August by a market research company. Telephone surveys have been shown to allow a large sample to be interviewed and positive response rates to be achieved and to provide reliable and accurate results (Denscombe, 2010). The questions were selected to obtain a general description of farm and farmer characteristics followed by specific questioning on the relevant grassland management practice. Considering the inexpensive nature and ease of use of the SRP it wasn't deemed necessary to include questions concerning experience, income, land tenure. Furthermore, the decision to omit these variables was also based upon the comprehensive review carried out on factors which influence farmer's adoption of best management practices by Prokopy et al. (2008). The study found that the influence of both experience and land tenure were inconclusive (Prokopy et al., 2008). These findings were further supported by a more recent review by Liu et al. (2018). Prokopy et al. (2008) also demonstrated that income is insignificant more often than it is positively significant when assessing factors that determine adoption. In an Irish context, Keelan et al. (2009) observed that neither land tenure nor income had any influence in determining the likelihood of adoption of Irish dairy farmers adopting GM technology. These findings of these studies guided the construction of the questionnaire used in this study and the psychological approach undertaken.

2.2. *Statistical analyses*

2.2.1. *Principal Component Analysis*

The questionnaire used homogeneous variables that expressed different TPB constructs. Principal Component Analysis (PCA) identifies common factors to account for most of the variation in data and is performed by examining the pattern of correlations among independent variables (i.e. questionnaire statements) (Field, 2009). The PCA was carried out on standardized variables. PCA allows us to empirically confirm the hypothesised TPB beliefs.

$$\begin{aligned} PC_1 &= \alpha_{11}\chi_1 + \alpha_{12}\chi_2 + \cdots + \alpha_{1I}\chi_I = \textstyle\sum_{i=1}^{I} \alpha_{Ii}\chi_i , \\ &\vdots \\ PC_J &= \alpha_{J1}\chi_1 + \alpha_{J2}\chi_2 + \cdots + \alpha_{JI}\chi_I = \textstyle\sum_{i=1}^{I} \alpha_{Ji}\chi_i , \end{aligned} \qquad (2)$$

For instance, α_{ji} represents the weight calculated for each belief χ_i across the $j = 1 \ldots J$ potential principal component (PC) (Eq. (2)). PCA determines the eigenvector α that maximises the variance λ given the constraint that $\sum_{i=1}^{I} \alpha_{ji}^2 = 1$. Thereafter, it attains a second linear function PC_2 that is uncorrelated with PC_1. The process is continued so that at the m^{th} stage, with $m \leq J$, a linear function of PC_m is found that has a maximum variance and is uncorrelated with other linear combinations. The attained variables are the principal components.

A PCA with varimax rotation was carried out to reduce the number of psychological variables to their underlying dimensions (Field, 2009). The 'grouped' variables or factors obtained from PCA were interpreted within the TPB. The Kaiser-Meyer-Olkin measure of sampling adequacy was found to be greater than 0.6 (0.808), thereby verifying that the dataset was appropriate for PCA. Subsequently, the Bartlett's test of sphericity was seen to be significant ($p < 0.05$), thus indicating that PCA could proceed (Pallant, 2010). Replacing the initial beliefs (A, SN, PBC) with the empirically identified principal components Eq. (1) becomes:

$$BI = \beta_1 PC_1 + \beta_2 PC_2 + \beta_3 PC_3 ... \beta_m PC_m + \varepsilon \quad (3)$$

2.2.2. *Cluster analysis*

Cluster analysis helps to account for heterogeneity within the sample. The components extracted from the PCA were subsequently used as classification criteria to cluster respondents into types (Bidogeza et al., 2009; Voss et al., 2009; Barnes and Toma, 2012; Hyland et al., 2016b; Morgan-Davies et al., 2011; Nainggolan et al., 2012). These groupings are internally homogenous, while being externally heterogeneous from one another (Janssens et al., 2008). Hierarchical cluster analysis was used to identify the optimal number of clusters based on Ward's method, which optimizes minimum variance within clusters (Mooi and Sarstedt, 2011). This method works by merging groups or cases resulting in the minimum increase in the within-group sum of squares. An elbow test verified the ideal number of clusters for the successive k-means clustering method (Table 4) (Mooi and Sarstedt, 2011).

The K-means method minimizes the distances within each cluster to the center of that cluster and was carried out following hierarchical cluster analysis. K-means methods are superior to the hierarchical methods when the choice is made for an initial configuration based on the results of hierarchical clustering (Janssens et al., 2008). Subsequently, respondents were grouped into their respective clusters. The types were labelled according to evident differences in their respective construct scores.

2.2.3. *Examining the heterogeneity of TBP beliefs across clusters*

PCA regression was used to identify the effects of the TPB beliefs on framers intention to use a SRP. Instead of adopting the original variables PCA regression involves using the principal components attained through PCA as independent variables (Aguilera et al., 2006). Intention was measured using a five-point Likert scale. Hence, ordinal logistic regression was applied with BI as the dependent variable and the identified principal components as independent variables. From this, estimate coefficients (β) were obtained. The integrated logistic-PCA regression model was applied to each cluster obtained from the previous cluster analysis. The central limit theorem, a tendency for asymmetric distribution of psychometric measures, and the robustness of multivariate regression to non-normality minimized any concerns about non-normality with sample sizes of $n \geq 30$ (Tipton, 2014).

PCA was initially employed to empirically confirm the TPB constructs and to avoid collinearity in regression analysis (Aguilera et al., 2006). PCA is limited in that important variables may reside in low Eigen value components or may have opposite signed influences which cancel over components. However, information attained from PCA and the ordinal logistic regressions can be used to identify the different effects of beliefs on intention. This method provides more detailed in- formation than obtained from regression analysis (Läpple and Kelley, 2013; van Rensburg et al., 2015). Therefore, two importance measures were constructed; namely, net importance I and absolute importance Ĩ of each respective belief. To obtain information about the importance of underlying predictor variables, we combine the regression parameters β with the factor loadings α (Läpple and Kelley, 2013; van Rensburg et al., 2015). This allows the calculation of the effect of heterogeneous beliefs on intention by inserting the linear combination of the principal components into Eq. (3):

$$BI = \beta_1 \sum_{i=1}^{I} \alpha_{1i}\chi_i^* + \beta_2 \sum_{i=1}^{I} \alpha_{2i}\chi_i^* + \beta_3 \sum_{i=1}^{I} \alpha_{3i}\chi_i^* , \beta_m ... \sum_{i=1}^{I} \alpha_{mi}\chi_i^* , + \varepsilon \quad (4)$$

The technique combines the estimated parameters β and component weights α and then sums the product of these parameters, for each underlying predictor in χ, and across the components observed to be statistically significant. The relative/net importance of a belief χ_i^* can be calculated using the following equation which is based on the linear combination of the J principal components and the calculated weights for each χ_i^*:

$$Y_1 = \beta_1 . [\alpha_{11}] + \beta_2 . [\alpha_{21}] + \beta_3 . [\alpha_{31}] + ... + \beta_m . [\alpha_{m1}]$$
$$\vdots$$
$$Y_I = \beta_1 . [\alpha_{1I}] + \beta_2 . [\alpha_{2I}] + \beta_3 . [\alpha_{3I}] + ... + \beta_m . [\alpha_{mI}] \quad (5)$$

It should be noted that only significant estimated regression estimates are used for calculation. The vector Υ_i represents the effect of χ_i *. The regression estimate coefficients are depicted by β, where α signifies the individual PCA weights (eigenvectors). The absolute importance is calculated using the following equation:

$$|\overline{Y_1}| = |\beta_1| . [|\alpha_{11}|] + |\beta_2| . [|\alpha_{21}|] + |\beta_3| . [|\alpha_{31}|] + ... + |\beta_m| . [|\alpha_{m1}|]$$
$$\vdots$$
$$|\overline{Y_I}| = |\beta_1| . [|\alpha_{1I}|] + |\beta_2| . [|\alpha_{2I}|] + |\beta_3| . [|\alpha_{3I}|] + ... + |\beta_m| . [|\alpha_{mI}|] \quad (6)$$

In order to determine the robustness of results the relative and ab- solute importance of each belief was assessed. Differences between the relative and absolute importance of a belief indicated that predictor effects may cancel out when summing across components. Thereby, indicating that the relative measure in Eq. (5) may underestimate the importance of a predictor.

2.2.4. *Descriptive statistical analysis*

Statistical analyses were undertaken on each cluster to characterise each identified cluster using means and standard deviations (continuous variables) or frequencies (categorical variables) for variables of central concern from the entire survey. Cluster comparison and validation was carried out by a one-way-analysis-of-variance. Furthermore, Pearson's Chi-Squared test (X^2) was used to determine whether groupings differed significantly in the frequency in which they answered questions not included in PCA analysis ($p < 0.05$).

3. **Results**

3.1. *Principal component analysis and cluster analysis*

The Kaiser-Meyer-Olkin measure of sampling accuracy was 0.668, indicating that PCA was appropriate (> 0.500). Moreover, Bartlett's test of sphericity was significant ($P \leq 0.001$) and, therefore it could be concluded that the strength of the relationship among the variables was high. Interpretation of the scree plot revealed inflexions that justified retaining four components (Pallant, 2010). The acquired factor loadings observed in Table 1 from PCA are the correlations among all individuals' answers to each of the questionnaire statements with the derived component score. A statement was retained if the loading factor was at least 0.35 (Janssens et al., 2008) and the difference between cross loadings greater than 0.30 (Wang and Ahmed, 2009). The content of a component was best interpreted by examining items with factor loadings of 0.40 or above, such factors are considered to be 'fair' (Costello and Osborne, 2011). Subsequently, the four principle components (PCs) were named: attitude (PC1), self-efficacy (PC2), resource

Table 1
Eigenvector weights for each of the 13 original variables according to the principal components (PC).

Questionnaire statement	PC1	PC2	PC3	PC4
A spring rotation planner can help increase production	0.826			
A spring rotation planner can help increase overall profits	0.814			
A spring rotation planner can help produce better quality milk	0.743			
A spring rotation planner can help ensure enough grass for the whole grazing season	0.709			
I have all the information I need to use a spring rotation planner		0.880		
I have a good understanding of how to use a spring rotation planner properly		0.798		
Conditions on my farm would allow me to use a spring rotation planner		0.504		
Would a member of your family recommend using a spring rotation planner		0.481		
A spring rotation imposes extra costs			0.816	
A spring rotation requires additional labour			0.759	
Following a spring rotation can be time consuming			0.745	
Are you aware of farmers in the area already using the spring rotation planner				0.794
Would your discussion group recommend using a spring rotation planner				0.738

Table 2
Final cluster centres of the four principal components (PC), as derived from the k-means cluster analysis for the classification of the 256 dairy farmers.

Principal Components	Clusters	
	1	2
PC1 (Attitude)	0.41	−0.35
PC2 (PBC; Self-Efficacy)	−0.13	0.11
PC3 (PBC; Recourse constraints)	−0.78	0.67
PC4 (Social Norm)	0.05	−0.04

Table 3
Socio-demographic, land, grazing management, spring rotation planner use, and knowledge acquisition profiles of the two farmer clusters.

Characteristics	High-Adopters	Low-Adopters
Gender (%)		
Male	97.5	93.5
Female	2.5	6.5
Age		
< 40	16.1	14.5
40-54	40.7	42.8
55-69	39.0	34.1
70 +	4.2	8.7
Education (%)		
Primary	10.2	19.6
Secondary	55.1	52.9
Third level	34.7	27.5
Agricultural degree	73.7	66.7
Agricultural college	12.7*	5.1*
Income (%)		
Off-farm income	48.3	49.3
Land (%)		
Poorly drained	12.7	13.1
Land fragmentation	73.7	65.9
Farm management (%)		
Use of farm map	83.9	77.5
Larger fields sub-divided	98.3	89.9*
Fields equal size	58.4	68.4
Spring Rotation Planner (SRP) (%)		
Familiarity of the SRP	64.4*	50.0*
Current use of SRP	64.5*	39.1*
Use of SRP in the past	69.7*	53.6*
If have used SRP: Divide the herd into grazing groups	39.8	4.06
If have used SRP: Set a turnout date	65.3	64.5
If have used SRP: Measure and record grass cover	38.1*	23.2*
If have used SRP: Test soil	90.7	88.4
If have used SRP: Apply nitrogen early	84.7	77.5
Intention to use SRP next year (Definite 'yes')	58.6*	34.4*
Knowledge acquisition (%)		
Discussion groups	54.2*	28.3*

* Significant ($P < 0.05$) association between categorical variables and High-Adopters and Low-Adopters after Bonferroni correction.

Table 4
Mean farm characteristics across each of the farmer clusters.

	High-Adopters		Low-Adopters	
	Mean	SD	Mean	SD
Size of farm (acres)	130.2	102.6	110.7	75.6
Size of herd (total)	84.2[a]	53.7	60.0[b]	36.6
Number of blocks/fragments	3.9	2.5	3.9	2.5
Number of individual paddocks	19.8	9.7	18.0	8.1
Number of grazing groups	3.8	2.1	3.9	4.3

SD represents standard deviation.
[a] Indicates significant differences ($p < 0.05$) between each cluster.
[b] Indicates significant differences ($p < 0.05$) between each cluster.

constraints (PC3), and social norm (PC4) (Table 1). Both self-efficacy and resource constraints can be described as perceived behavioural controls.

The PCA scores were used for the Ward's hierarchical clustering technique (Mooi and Sarstedt, 2011). The selection of a final cluster solution requires substantial researcher judgement (Hair et al., 1998). The application of the hierarchical cluster analysis suggested the presence of two clusters from interpretation of the dendrogram (Köbrich et al., 2003). The final cluster centres were computed as the mean for each PC variable within each final cluster derived from the k-means cluster analysis. The final cluster centres reflect the characteristics of the typical case for each cluster (Table 2). All the clustering variables' means differ significantly across all the clusters. Hence, the final cluster centres interpret what is typical for a particular cluster. Therefore, the means of all clustering variables were used to interpret and name the segment. Multiple comparisons of cluster means are presented in the Appendix A (Table A1). Table 2 depicts the final cluster centres for High-Adopters (Cluster 1) and Low-Adopters (Cluster 2).

3.2. *Cluster characteristics*

Tables 3 and 4 illustrate the frequencies, means and standard deviations for categorical and continuous questionnaire variables, as well as the statistical differences among clusters. All clusters shared some common characteristics. Further description of each cluster follows:

3.2.1. *Cluster 1: High-Adopters (n = 118, 46.1%)*

The cluster was characterised by having significantly higher adoption rates of the spring rotation planner. This was observed in the significant association between cluster membership and current use of the SRP (65%) (Table 3). Furthermore, they held a more positive attitude towards spring rotational grazing. They perceived less resource constraints than Low-Adopters and scored high in their knowledge of the system. High-Adopters had a significantly larger herd size than Low-Adopters but there were no substantial difference between the two clusters for other farm characteristics. A significant relationship was observed between attending agricultural college and cluster membership. What's more, there was a significant association between High- Adopters and membership of a discussion groups. A significantly higher proportion of farmers within the cluster deemed themselves familiar with how to use the spring rotation planner. Of those who had previously used the spring rotation planner a significantly higher number of farmers measured and recorded grass growth. A significantly higher proportion of farmers in this cluster stated their intention to use the SRP next year.

3.2.2. *Cluster 2: Low-Adopters (n = 138, 53.9%)*

There was a significant association between cluster membership and lower current use of the SRP (40%) (Table 3). Low-Adopters were characterised by their high sense of resource constraint despite an appreciation that they were capable of implementing the SRP. Indeed, they were similar to High-Adopters in terms of their self-efficacy in implement the grazing system. The cluster had a significantly lower herd size than Adopters of the SRP. There was a significant association between farmers in the cluster and the sub-division of fields, with a low percentage of its members taking part in the management practice. Furthermore, there was a significant association between cluster membership and familiarity of using the SRP. There was also a significant association between cluster membership and lower past use of the planner when compared to High-Adopters. There was a significant association between the cluster and low grass measurement and re- cording of grass growth if they had previously used the SRP. A significantly lower proportion of farmers also stated that they intended to use a SRP grazing next year. With regards to education, a significantly lower proportion of Low-Adopters attended agricultural college and were part of a discussion group.

Table 5
Results of ordered logistic models for the PCA beliefs for each cluster

	High-Adopters		Low-Adopters
	β	P value	β
Attitude	1.22	0.001	1.249
PBC: Self- efficacy	1.061	0.000	0.856
PBC: Resource constraints	−1.037	0.007	−0.905
Social Norm	0.262	0.265	0.280
Nagelkerke R^2	0.400		0.376

Table 6
The relative and absolute importance of individual beliefs on intention to use SRP next year for each cluster.

	High-Adopters		Low-Adopters	
	Relative	Absolute	Relative	Absolute
Attitude				
A SRP can help increase production	1.00	1.14	1.02	1.14
A SRP can help increase overall profits	1.20	1.20	1.19	1.19
A SRP can help produce better quality milk	1.18	1.18	1.15	1.15
A SRP can help ensure enough grass for the whole grazing season	0.99	0.99	0.99	0.99
PBC: Self- efficacy				
I have all the information I need to use a SRP	1.04	1.04	0.86	0.86
I have a good understanding of how to use a SRP properly	1.03	1.14	0.88	0.97
Conditions on my farm would allow me to use a SRP	0.71	0.71	0.60	0.60
Would a member of your family recommend using a SRP	0.74	0.74	0.64	0.64
PBC: Recourse constraints				
A spring rotation imposes extra costs	−0.84	0.85	−0.73	0.74
A spring rotation requires additional labour	−0.83	0.92	−0.71	0.80
Following a spring rotation can be time consuming	−0.87	0.92	−0.78	0.82
Social Norm				
Farmers in the area that are already using a spring rotation	−0.06	0.23	−0.03	0.21
Would your discussion group recommend using a SRP	0.05	0.09	0.06	0.09

3.3. *Effects of individual beliefs on intention*

Information from PCA and regression estimates may be used to identify the different effects of beliefs on intention to adopt the SRP. The influence of the four principal components on intention to adopt the SRP was subsequently assessed separately for each of the two clusters using an ordered logistic regression model (Table 5). It was observed for High-Adopters that attitude, self-efficacy, and resource constraints were significantly related to intention. Conversely, there was no significant association between the principal component social norm and intention. Similarly, with the exception of social norm there was a significant relationship between all other principal components and intention for Low-Adopters.

While the estimate coefficients of the logistic regression model provide information about the aggregated effect of beliefs, they do not provide insights into the underlying beliefs on intention. Therefore, the relative and absolute importance of the underlying beliefs was calculated using Eqs. (5) and (6). The effects of the individual beliefs are presented in Table 6. Absolute intention should exceed or equal relative importance for a predictor. If the relative score is smaller, this indicates that a variable's influence is having positive and negative impacts across multiple principal components that cancel when summing to recover its score. Thereby, indicating that the relative score is under- estimating the true importance of a variable. When both relative and absolute scores are equal it denotes the variable has the same signed influence across all principal components (van Rensburg et al., 2015).

The PCA results from Table 6 are able to provide more detailed insights into the impacts of underlying beliefs. By focusing on the relative and absolute values of the two clusters it was possible to observe each formative beliefs effect on intention. Performing a robustness check by comparing the relative and absolute importance within each cluster provided insight to the extent to which underlying beliefs may cancel each other during summation across multiple principal components.

Both High-Adopters and Low-Adopters were analogous in terms of the relative and absolute importance of certain beliefs in forming their respective intention to adopt the SRP for next year. For both clusters of farmers attitudinal beliefs such as ‘a SRP can help increase overall profits’, ‘a SRP can help produce better quality milk’, and ‘a SRP can help increase production’ were found to be most influential towards intention. These were followed by beliefs associated with self-efficacy for both sets of farmers; namely ‘I have all the information I need to use a SRP’ and ‘I have a good understanding of how to use a SRP properly’. Resource constraint beliefs were observed to be least influential on intention for High-Adopters and Low-Adopters in regards to their respective relative importance. However, when absolute importance was assessed it was found that such beliefs were underestimated and had a greater impact on intention than relative importance suggested. Beliefs that local famers and their discussion group would recommend using a spring rotation planned were observed to be of least importance when assessed in absolute terms for both clusters.

4. **Discussion**

Farmer’s individual approaches to grazing may vary spatially and temporally. Nevertheless, there are likely to be consistent characteristics and patterns of value systems, motivations and social and economic factors which influence their respective grazing practices (Bohnet et al., 2011). The use of the SRP has been promoted as a best management practice with production benefits and associated higher revenue. On-farm grass utilisation amongst Irish farmers is low with significant potential for expansion and increased efficiency (Creighton et al., 2011). This poses a major challenge to policy makers and agricultural extension program designers who aspire for the maximum uptake of best management practices. Potential reasons for the non-adoption of best practices for cattle farmers include unfamiliarity, non- applicability, high cost, still considering adoption, and preference not to adopt (Gillespie et al., 2007). The use of landholder typologies has been recommended to improve the effectiveness of agricultural policies and extension programs (Emtage et al., 2007). The purpose of this study is to establish a typology of Irish dairy farmers based on their perceptions of the SRP. The findings may be extrapolated to aid policy-makers in other temperate regions to encourage farmers in adopting measures that aim to increase grass utilisation.

The TPB is a useful model to determine the motivational factors that underlie farmers’ intention (van Dijk et al., 2016). The findings of this study suggest that the factors that influence the decision of farmers to reject or accept a grazing innovation is not uniform. Two clusters of farmers were elicited from the analyses based on farmers' beliefs of using the SRP. The two groups did not differ in most of their socio- economic characteristics. Variance in adoption rates of a technology may be explained by: relative advantage (e.g. economy and status); compatibility (e.g. values, norms and practices); and complexity (difficulty in understanding and usage) (Rogers, 2003). Low-Adopters of the SRP were characterised by their high sense of resource constraint despite feeling that they were capable of implementing the grazing system. Recent Irish research has also identified this to be a significant factor influencing beef farmers adoption of rotational grazing (Hyland et al., 2018). While the rotational grazing system investigated in that study is not as formal as the SRP, and differs quite substantially in terms of structure, the results of both studies suggest that a sense of recource constraint to be a limiting factor in the adoption of grazing systems across the beef and dairy sectors. Although financial gain is important to many farmers, Key (2005) depicts how attributes such as independence are considered significant. The SRP requires a defined plan that dictates the time period that livestock graze; some farmers may see this as restrictive and may prefer a more flexible approach to rotational grazing. Furthermore, economists have often assumed that money can act as a substitute for utility which has led to many agricultural economic models assuming that all farmers are rational profit maximises (Edwards-Jones, 2006). Such an approach may not consider the behaviour of individual farmers as it fails to recognise that farmers' behaviours are affected by a variety of farming goals (Howley et al., 2015; Pampel et al., 2006; Vanclay, 2004; Willock et al., 1999a, 1999b). While maximising profits will be important to a certain cohort of farmers, for others, such as Low-Adopters, it may not be their sole incentive for farming and may therefore explain their attitude towards the management practice. However, Morgan-Davies et al. (2011) found that resource constrained farmers are often vulnerable and are more likely to continue the current trend of reductions in size of business and of risk of farm abandonment. Conversely, High-Adopters were defined by a more positive attitude towards the SRP. High-Adopters perceived less resource constraints than Low-Adopters but were comparable in their sense of self-efficacy in how to implement the grazing tool.

By accounting for individual belief heterogeneity it was possible to access the importance of all beliefs in terms of their influence on intention to adopt the SRP. While the results were significant, the R^2 values for the ordered logistic regression analyses were low for each cluster model. The psychological constructs assessed in the regression could, therefore, be misinterpreted as playing a small role in intention and that considerable amount of variance remains unaccounted. However, Cohen (1988) defined strong, moderate, and weak effects for regression analysis as corresponding to effect sizes of approximately 0.26, 0.13, and 0.02, respectively for behavioural and social sciences. Alternatively, Ferguson (2009) suggests R^2 values of 0.64 0.25 0.04 as strong, moderate, and weak for social sciences. The results reveal that the PCA construct attitude was highly significant with regard to intention of adoption of the SRP. It was observed that individual attitudinal beliefs had the greatest influence on intention to adopt the SRP for both cohorts of farmers. Garforth et al. (2004) observed that attitude toward a technology had a strong influence on farmers' intention to adopt. Similarly to the findings of this study, both Martínez-García et al. (2013) and Borges et al. (2014) established that attitude had a significant influence on the intention of farmers to use improved grassland.

In a review of the literature focused on the adoption of agricultural best management practices Prokopy et al. (2008) found adoption was dependent upon the utilisation of social networks. However, people can be unware of the influence of subjective norm and normative beliefs on their actions and therefore tend to deny the influence of others (Nolan et al., 2008). People thereby generally deny the influence by important others when asked about it. This may explain why beliefs which represented social norms were least influential in farmer's intention to adopt the SRP. Another reason for the influence of social norm is the observability of the innovation. Management practices that are observable by others are more likely to be adopted (Reimer et al., 2012). The SRP is not necessarily observable, in that it is hard to distinguish it from normal rotational grazing, which may also explain the low influence of social norms. Martínez-García et al. (2013) promotes the need for further research on how social norms may vary depending on the innovation studied.

An established method of conceptualising change at farm level is Roger's diffusion of innovations approach. Rogers (1995) designated a set of five stages by which innovations are adopted: knowledge, per- suasion, decision, implementation, and confirmation. The farmer is exposed to the innovation during the initial stage of adoption, but is not motivated to learn more about it; thereafter, the individual becomes interested and actively seeks out information; in the third stage an adoption decision is made; in the fourth stage the innovation is implemented (to varying degrees) and finally the decision is made to fully implement the innovation. However, adoption of management techniques are complex may not follow patterns predicted by diffusion.

Wilson (2008) argues that transition at farm level is a complex non- linear process that is consequently somewhat unpredictable. Wilson outlines the importance of resource capacities and priorities held by farmers, and the varying levels of constraint positioned on farmers with regards to their ability to adopt new innovations. Diffusion theory has been shown to be a poor predictor of adoption when considering some management practices; especially those that are environmentally focused (Padel and van Es, 1977; Padel, 2002). Vanclay and Lawrence (1994) argued that the non-adoption of practices may be based upon rationality and depend on the characteristics and complexities of the innovations. This could include the need for a whole system change, incompatibility, economic disadvantages, conflicting information, and reduced flexibility in management decisions. Saltiel et al. (1994) found that found that for low-input methods (which the SRP could be classified) the type of farming enterprise played a significant role in the adoption of sustainable agricultural practices. Conversely, Perry-Hill and Prokopy (2014) deemed that small landowners were more willing to try conservation practices. The literature therefore suggests that the adoption of management techniques is complex and may not follow patterns predicted by diffusion-innovation theory. Bounded rationality may explain some of the inconsistencies observed in farmer's decision making (van den Bergh et al., 2000).

Weber (1997) proposed a 'finite pool of worry', which implies that individuals have a limited capacity as to how many issues they deem relevant at any one time. Farmers therefore may feel compelled to align management decisions towards actions that may be implemented easily. Indeed, this limited capacity to prioritise relevant issues could be a limiting factor for Low-Adopters. While those in the cluster perceived themselves capable on implementing the management practice they were constrained by numerous resources such as cost, labour, and time. Creighton et al. (2011) demonstrated that grassland management technology does not appeal to Irish farmers due to the requirement for new skills development, attention to detail and long-term commitment. Nonetheless, Irish dairy farmers are more susceptible to innovation adoption than farmers in other sectors (Läpple et al., 2015). Adopters of best management practices are generally exposed to more information and have greater resources to devote to their farm operation (Gillespie et al., 2007). Indeed, El-Osta and Morehart (1999) found that education and size of operation positively impacted the decision of dairy farmers to adopt a management-intense technology. It was therefore somewhat unsurprising that High-Adopters had a significantly larger herd size and that a significantly higher proportion of their cluster attained education from an agricultural college and were part of a discussion group.

Irish agricultural education emphasises the important role of grazing systems and most have dedicated modules dedicated to grassland management. Upon further investigation it was found that there wasn't a significant correlation between having an agricultural education and the attitudinal component of the PCA. This suggests that education doesn't define attitude towards the SRP but it does influence ones intention to adopt it. Discussion groups are farm extension meetings of dairy farmers organised by a dairy advisor. Typically, such groups meet regularly at a host farmers' farm to discuss a specific topic (i.e., grazing management, artificial insemination, production costs, or animal health). The importance of discussion groups was highlighted in an Irish context by Hennessy and Heanue (2012) who found that membership had a positive impact on technology adoption. McDonald et al. (2016) suggests that increased education and training can contribute to an increase the rate of grassland management technology adoption on Irish farms in future. O'Donoghue and Heanue (2016) confirm that Irish farmers with formal agricultural education have higher rates of adoption of grassland management practices. The results provide policy makers and agricultural extension program designers with critical social information to more effectively tailor their policies and programs aimed at influencing grazing management practices. The careful design of extension efforts addressing adoption of the SRP could consequently assist in overcoming some of the barriers identified.

Various epistemologies influence the mobilization and transformation of knowledge. The traditional knowledge-transfer approach has been criticised as it fails to adequately address heterogeneity within the farming community (Klerkx et al., 2012). The limitations of the traditional paradigm led to the formation of non-didactic 'human development' approaches, which are based on participation and empowerment (Black, 2000; Fleming and Vanclay, 2010).

Lankester (2013) demonstrated how organised collective group learning is an effective method of fostering behaviour among Australian beef farmers. Social learning bases its philosophy on participation and integrating knowledge from different perspectives and involves critical thinking, interactions, dialogue, and questioning assumptions that underline individual concepts (Leeuwis et al., 2002). This approach would allow individuals to discuss their perceptions on grassland management with each other and experts.

The SRP has long been established in New Zealand and its success is based upon the focus on an efficient grass based dairy sector. As Ireland transitions to a non-milk quota era it is important that the planning tool is more widely adopted. Participatory approaches foster innovation uptake by farmers as they involve farmers working closely with advisors and other farmers to come up with applicable solutions to the challenges they face (Douthwaite et al., 2009). For example, a number of participatory approaches could be implemented in farmer discussion groups to enable the host farmer to consider key criteria that may affect their choice of priority actions when implementing the SRP (Macken-Walsh, 2017).

Läpple et al. (2015) suggest the creation of centres of excellence which would foster the co-creation of knowledge that is better adapted to the needs of farmers. Such centres would focus on particular aspects of dairy farming and provide professional development courses; thereby, strengthening the relations between research, education, extension and farmers.

5. Conclusions

Ireland has recently outlined ambitious production targets for the dairy sector. In order for industry to realise these objectives it's imperative that Ireland fully exploit its climatic advantages and maximizes the level of grass utilization. However, grass utilisation on Irish dairy farms is low and in an effort to address this issue the SRP has been adapted from New Zealand. The results suggest disparity between farmers' perceptions of the grazing tool with significant differences in attitudes towards the planner between High-Adopters and Low-Adopters. It is therefore recommended that tailored knowledge dissemination may assist in greater uptake (Knowler and Bradshaw, 2007; Liu et al., 2018). Tailored knowledge dissemination can be defined as "any combination of strategies and information intended to reach one specific person based on characteristics that are unique to that person, related to the outcome of interest and derived from individual assessment" (Kreuter et al., 2000). Targeted interviews with both advisors and farmers could be used to establish how to best tailor information towards farmers to increase uptake of the SRP. Although the human development model is seen as an improvement on the knowledge- transfer approach, no single model is likely to be sufficient by itself for effective knowledge exchange and/or knowledge transfer (Black, 2000). Furthermore, information sources that are trusted by farmers should be used, irrespective of the model used (Reed et al., 2014). Research suggests that in engendering trust longevity and expertise in advisory services are of greater importance to farmers than the public, private or charitable status of a specific advisory service (Sutherland et al., 2013). Investigating the role of trust in farmer's decision making was outside the scope of this study. Nevertheless, it would be of particular interest for future research to consider the role of trust on influencing Irish dairy farmer's adoption of innovative practices. This could be achieved by considering farmers access to and use of in- formation as mediated through risk and trust as demonstrated by Sligo and Massey (2007) in their study of New Zealand dairy farmers. The fact that no one knowledge dissemination paradigm suits all further illustrates the importance of recognising the heterogeneity within the farming sector. Hence, carefully planned communication, targeted at the different farmer types, can help encourage a positive change in farm management practices that promote the SRP.

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Conflict of interest

None.

Appendix A

Table A1
Multiple comparisons of cluster means.

Principle Component	Cluster (I)	Cluster (J)	Mean Difference (I-J)	Std. Error	Sig
Attitude	1	2	0.76	0.12	0.000
Self-efficacy	1	2	−0.24	0.12	0.054
Resource constraint	1	2	−1.45	0.09	0.000
Social Norm	1	2	0.09	0.13	0.456

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