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Research article

Which factors influence farmers' intentions to adopt nutrient management planning?

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ABSTRACT

The adoption of nutrient management practices can lead to win-win outcomes in terms of both improving productivity and reducing the environmental impact of farming. However, adoption of key practices remains below expectations globally. Few studies specifically focus on the adoption of nutrient management practices and the majority overlook psychological factors in their analysis. This study examines the factors which influence Irish farmers' intention to apply fertiliser on the basis of soil test results. An expanded version of the theory of planned behaviour is used as a framework for analysis. The influence of policy is also accounted for by this study which requires certain farmers in Ireland to adopt soil testing on a mandatory basis. The results for the national sample (n = 1009) show that attitudes, subjective norms (social pressure), perceived behavioural control (ease/difficulty) and perceived resources are significant and positively associated with farmers' intentions. In terms of the voluntary sample (n = 587), only attitude, perceived behavioural control and perceived resources are significantly and positively associated with farmers' intentions. Whereas, for the mandatory sample (n = 422), subjective norms, perceived behavioural control and perceived resources are significantly and correlated in a positive direction with intentions. A number of farm and farmer characteristics are also significantly associated with intentions. Policy recommendations are made based on these results.

1. Introduction

The past five decades have seen a rapid increase in demand for food, owing to a persistent increase in the global population and a dietary shift towards a larger share of meat and dairy products (Lassaletta et al., 2016; Swain et al., 2018). To meet this demand, food production has intensified, with crop production per unit of area increasing due to increasing inputs of nutrients among other factors (Nesme et al., 2018). Nutrients, such as nitrogen (N), phosphorous (P) and other micronutrients, such as magnesium, manganese and cobalt, are essential for the continued growth of global agricultural production. However, nutrients, especially N and P, also have the potential to cause environmental degradation (Lu and Tian, 2017; Lun et al., 2018). Global concerns over the nutrient enrichment of both ground and surface waters and the direct emissions of nitrous oxide and ammonia into the atmosphere have led to the simultaneous regulation of nutrient use on farms in various countries (Sutton et al., 2011) and the promotion of management practices that can both increase productivity and reduce environmental damage (Gebrezgabher et al., 2015; Hyland et al., 2018). Effective nutrient management has been advocated as one key area requiring improvement globally (Mueller et al., 2012; Pasuquin et al., 2014; Xu et al., 2016).

Nutrient management is a process of planning for manure and fertiliser applications to individual pastures or crop fields (Oenema and Pietrzak, 2002). However, decision making surrounding this process is often influenced by the particular farm system in question (e.g. cattle, dairy, sheep or tillage) (Beegle et al., 2000). For example, livestock based farming systems may have a larger emphasis on decision making surrounding manure management whereas tillage farms may have a larger emphasis on decision making surrounding the use of chemical fertiliser. However, regardless of farm system, as the ultimate goal of nutrient management is to match nutrient supply with grass or crop

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demand, the decision to adopt is relevant across all farm systems (Goulding et al., 2008; Roberts and Johnston, 2015). However, it is important to note that whilst nutrient management is applicable to all farm systems the incentive to adopt may differ which can influence the decision to adopt. For example, intensive dairy or tillage farm systems often require larger quantities of fertiliser inputs and therefore the incentive to adopt practices that help to optimise returns from nutrients may be higher than low intensity cattle or sheep production systems (Beegle et al., 2000). Soil testing is a key, though not sufficient, nutrient management practice that can be adopted to achieve the aims of nutrient management regardless of farm system (Kelly et al., 2016).

Whilst soil testing remains readily available in a developed world context, adoption remains below expectations across all farm systems (Kelly et al., 2016; Bruyn and Andrews, 2016). A situation has also been observed whereby farmers who do adopt soil testing often fail to fully translate these data into decision making surrounding fertiliser applications (Buckley et al., 2015; Bruyn and Andrews, 2016; Kannan and Ramappa, 2017). This potentially forgoes some of the benefits that otherwise could be gained. Despite global efforts to improve uptake, there remains an international challenge in encouraging the use of soil analysis in decision making and the adoption of nutrient management practices on a wider scale (Osmond et al., 2015; Collins et al., 2016; Wang et al., 2018). Research has shown that the lack of incorporation of soil analysis in decision making may be due to a lack of awareness, lack of perceived benefit, cost, difficulties with implementation and preference not to adopt (Brant, 2003; Osmond et al., 2015; Micha et al., 2018). Non-adopters may prefer to rely on, for example, personal experience, tradition and 'informed' intuition to influence nutrient management decisions (Nuthall and Old, 2018). However, variance in adoption and use is often found to be contingent on factors which are under the control of the farmer such as the extent of adoption and management skill (Oenema and Pietrzak, 2002; Roberts et al., 2017).

Very few studies have examined the determinants of adoption of soil testing. Moreover, most of the literature focuses on the factors which influence the adoption of individual nutrient management practices (Bosch et al., 1995; Caswell et al., 2001; Monaghan et al., 2007; Ribaudo and Johansson, 2007). Thus, less attention is given to the simultaneous adoption of a given nutrient management practice and its translation into on-farm decision making. Thus, we address a specific gap in the literature by examining farmers' intentions to simultaneously adopt soil testing and apply fertiliser on the basis of soil test results. Furthermore, previous studies have primarily focused on examining the influence of farm and farmer socio-economic factors on adoption of nutrient management practices and, as such, the underlying psychological factors (e.g. beliefs and social pressure) which affect farmer decision making are often overlooked.

Some authors have argued that a failure to account for the influence of psychological factors on behaviour may lead to an incomplete understanding of farmers' intentions towards such management practices (Borges et al., 2014; Wilson et al., 2014; Zhang et al., 2016; Zeweld et al., 2017). Following these authors, we extend the literature by developing a conceptual framework based on the Theory of Planned Behaviour (Ajzen, 1991) in order to advance our understanding of the factors which influence farmers' intentions to apply fertiliser on the basis of soil test results. This will help policy makers to better target initiatives at the factors which hinder and drive the uptake of this important nutrient management practice.

This study seeks to add to the literature by examining which factors influence farmers' intentions to apply fertiliser on the basis of soil test results, which has seldom been studied. As all farm types or systems have the potential to benefit from the use of soil testing, this study is not restricted to a particular farm system. This study uses the Republic of Ireland (henceforth Ireland) as a case study from which generalised lesson can be drawn for better targeting initiatives designed at encouraging farmers to apply fertiliser on the basis of soil test results. These recommendations are also relevant more widely as many countries face the challenge of encouraging farmers to improve their nutrient management practices.

2. Description of soil testing

Soil testing is a diagnostic tool which helps farmers to assess current soil fertility and pH levels of individual fields and make fertiliser application decisions based on these and expected crop yield (Adusumilli and Wang, 2018). Without analysing the nutrient status of fields, the risk of over or under applying nutrients to fields with suboptimal soil pH or fertility levels is increased (Robert, 1993). This can increase the risk of nutrient loss to the environment, lead to lower crop yields and an increase in the risk of sub optimal financial returns to the farmer (Sharpley et al., 2003). The most commonly used test in Ireland is for pH and the macronutrients P and K which costs around €25 per sample. General recommendations for nutrient applications, including liming requirements, are provided in a soil analysis report by registered soil testing laboratories. It is typical for farmers to refine these recommendations based on personal experience, tradition, external advice and expected crop yields. Some of the benefits of following recommendations made by soil analysis include increased yields, improved crop quality and efficiency of input use (Robert, 1993). However, recommendations based on soil test results can incur additional costs such as the need to seek external advice and increase fertiliser and lime inputs in the short run. On the other hand, a soil test may indicate the need to reduce fertiliser application rates which the farmer may perceive as risky as application of fertiliser in excess is often viewed as a risk off-setting activity that helps to ensure high yields and economic stability (Sheriff, 2005; Stuart et al., 2014). For these reasons, farmers may be averse to stringently following recommendations based on the results of soil analysis.

There are several factors which drive the adoption of soil testing in Ireland. These include water quality policy, nutrient management regulation, agri-environmental scheme entry and farm management (Shortle and Jordan, 2017). In Ireland, the adoption of periodic soil testing is mandatory for farmers who receive a derogation (allowance) to operate at a higher stocking rate, of above 170 kg/N/ha^{-1}, under the European Union Nitrates Directive (ND) regulations (European Comission, 1991). Farmers who apply to enter and receive subsidy payments under the 'Green Low Carbon Agri-environment Scheme' (GLAS) are also required to conduct periodic soil testing (Image, 2016). However, there is evidence which suggests that farmers who adopt soil testing on a mandatory basis may not rigidly follow recommendations when making nutrient management decisions, which is not an explicit requirement as it is hard to regulate (Buckley et al., 2015). Similar to other countries (Kania et al., 2014), a number of initiatives are also used to encouraged farmers to voluntarily adopt soil testing and to translate the results into practice. These initiatives include knowledge transfer and exchange through, for example, agricultural education courses, national advisory services, open days, farm walks and farmer discussion groups (Prager and Thomson, 2014).

3. Conceptual framework

In order to examine the factors which influence farmers' intentions to apply fertiliser on the basis of soil test results, we developed a conceptual framework based on the Theory of Planned Behaviour (TPB), formulated by Ajzen (1991) to explain human behaviour. According to the TPB, intention is an appropriate predictor of actual human behaviour. Intention, in turn, depends on the beliefs held by the individual towards a particular behaviour which are based around three constructs. These include attitudes towards the behaviour, the perceived social pressure from significant others to perform the behaviour (subjective norms) and perceived behavioural control, which incorporates the perceived ability to perform the behaviour.

The TPB framework has been validated and shown to provide a