Drivers and barriers to adopt best management practices. Survey among Italian dairy farmers

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Highlights

- Barriers limit the adoption of crop best management practices in Italian dairy farms
- Farmers are well aware of the benefits of their adoption
- The increase of direct and indirect costs emerged as the main explicit barrier
- A favourable environment of referents around farmers could enhance adoption

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Abstract

Best management practices that could improve sustainability of dairy farming systems in northern Italy include crop rotation, green manure, sprinkler or drip irrigation, incorporation of crop residue, and adoption of a nutrient management plan. Despite the numerous advantages that scientific literature reports for these Best management practices, they are not always adopted by farmers, because other factors – of financial, technical, or social nature – limit their adoption. The theory of planned behaviour, based on the identification of outcomes, referents surrounding the farmers, and control factors, was applied through a detailed questionnaire to study individual farmer beliefs that influence the intention to adopt best practices. More than 50% out of the farms applied incorporation of crop residue, rotation with a grass or a legume meadow, sprinkler or drip irrigation, and adopted a nutrient management plan. Reasons for applying them were mainly related to soil sustainability (improvement of soil organic matter content, soil structure, fertility and yield) or to environmental sustainability (reduction of nitrogen losses, use of fertilizers, herbicides or insecticides). Among the main barriers to their adoption, the most important ones were an increase in direct or indirect costs. The only practice that was not adopted and, despite a limited number of barriers, will not be adopted by farmers, is green manure. Likely, our survey did not capture the real barriers against the adoption of this practice. Across all best management practices, the main difference between adopters and non-adopters was found in referents' opinion on applying them. This means that it is very important, for the adoption of best management practices, that the community of family members, neighbor farmers, and various advisors, are in favour of adoption. This important finding should be used by public authorities to promote the development of focus groups, demonstration days, demonstration farms, and especially good and updated independent farm advisors who could substantially increase the adoption of best management practices by farmers.

Keywords

Crop residue; Green manure; Irrigation; Temporary meadow; Theory of planned behaviour; Nutrient management plan.

1. Introduction

Most dairy farming systems in northern Italy have a number of characteristics that make them particularly intensive. They rely on cereals produced on-farm and on feed inputs from outside the farm. The livestock number per farm unit, animal productivity and stocking rate (number of heads per unit of cultivated area) are generally high (Bassanino et al., 2007). Animals are kept in a stable all year round. Faeces and urine are collected as slurry and – to a minor extent – as farmyard manure, and then used as fertilisers for forage crops.

Studies carried out in the recent past question about the sustainability of these farming systems because of issues related to excessive or unbalanced N loads (Bechini and Castoldi, 2006; Bassanino et al., 2007; Bassanino et al., 2011), P loads (Castoldi et al., 2009a and 2009b) soil cover (Bechini and Castoldi, 2009), biodiversity, gaseous emissions (Alluvione et al., 2010), water management (Gaudino et al., 2014), and weed management (Castoldi and Bechini, 2010a and 2010b). Since manure nutrients are not completely accounted for when calculating the application rates of mineral fertilisers, too much N and P are commonly applied to soils of these farms. Other environmental threats are an insufficient winter soil cover, as most of farm area is cultivated with maize; a low crop diversity (because the forage system relies on a rather small number of species - mostly maize, both as silage and for grain, and to a minor extend wheat, barley and alfalfa); and inefficient irrigation, as frequently applied using the surface system. Low levels of soil organic matter (SOM) are not an issue, mainly due to abundant applications of animal manure (Bechini et al., 2011).

Best Management Practices (BMPs) that could mitigate these sustainability problems are crop rotation, incorporation of a green manure, sprinkler or drip irrigation, incorporation of crop residue, and adoption of a nutrient management plan. Crop rotation diversifies the crops cultivated and reduces weed and pest issues. Without rotation, high production levels can be assured only by the use of mineral fertilizers and pesticides (Mitchell et al., 1991; Crookston et al., 1991; Bullock, 1992). Incorporation of a green manure provides winter soil cover between two summer crops, thus contributing to reduce nitrate leaching (Kuo and Sainju, 1998; Lemaire et al., 2004; Tonitto et al., 2006), reduce wind and water erosion (García-González et al., 2018), control weeds and pests (Cherr et al., 2006; Osipitan et al., 2018), contribute to N supply (Gselman and Kramberger, 2008; Vaughan et al., 2000), and improve soil fertility by increasing soil organic matter (Poeplau and Don, 2015). Sprinkler and drip irrigation are more efficient compared to surface irrigation and thus contribute to reduced water consumption and nutrient leaching (van der Kooij et al., 2013; Gadanakis et al., 2015). Crop residue incorporation, compared to residue removal, contributes to maintain or increase soil organic matter (Zibilske and Materon 2005; Dong et al 2009; Lehtinen et al., 2014), improves soil structure (Powlson et al., 2011), reduces soil erosion due to mulching, enhances soil life (Perucci et al., 1997), and may contribute to crop nutrition (Buyanovsky et al., 1994; Paustian et al., 1997; Palm et al., 2014)

Despite a number of advantages scientific literature reports for these BMPs, they are not always adopted by farmers, suggesting that other factors – of e.g., financial, technical, or social nature – influence their adoption. Quantitative information is lacking in Italy about the adoption rate of these practices and the reasons why the adoption rate is high or low.

Figure 1

A better understanding of the drivers and barriers to BMP adoptions by farmers may result from the adoption of a behavioral approach, which means investigating the decision-making process of individual farmers using quantitative methodologies (Burton, 2004; Edwards-Jones, 2006). The theory of planned behaviour can be used to study individual farmer's beliefs and understand the intention to adopt agricultural management practices. According to this theory, individual beliefs about a behaviour or practice determine intention and behaviour (Ajzen, 1988; Ajzen, 1991). The intention to behave increases the probability that an individual will actually perform a certain behaviour. The intention of a farmer to adopt a BMP is influenced by the benefits the farmer perceives as connected to the adoption of the practice (attitude), the feeling of social pressure from others towards adoption (subjective norm), and the subjective beliefs about the ease or difficulty of successfully performing the BMP (perceived behavioural control) (Figure 1). More in detail, the theory of planned behaviour states that attitude is thought to be a function of the belief that the behaviour will be associated with a set of outcomes (behavioural belief strength), weighted by an evaluation of these outcomes (outcome evaluation). Subjective norm is formed by how much we perceive others (called referents) think we should perform the behaviour (normative belief), weighted by our motivation to comply with these referents. Finally, perceptions of behavioural control depend on the belief that a set of control factors facilitate or obstruct the behaviour (control strength), weighted by the expected impact that these factors would have if they were present (control power). All these underlying subjective beliefs influence a farmers' intention to adopt a certain practice, and are acting as cognitive drivers or barriers which encourage or discourage the farmer to adopt a specific practice. This theory has been successfully applied in agriculture to understand farmers' behaviour for example by Beedell and Rehman (2000), Wauters et al. (2010), Wauters and Mathijs (2013), Martínez-García et al. (2013), Borges et al. (2014), Borges et al. (2014), Yazdanpanah et al. (2014), Donati et al. (2015), Sereke et al. (2015), Bechini et al. (2015), Lalani et al. (2016), and Bijttebier et al. (2018). All these authors have applied the theory of planned behaviour to investigate reasons for adopting or not adopting one single practice, in few cases two or three practices. Lalani et al. (2016) analyzed reasons for endorsing conservation agriculture techniques in Africa. Martínez-García et al. (2013) unraveled the processes behind adoption of techniques to improve grassland quality in Mexico. Similarly, Borges et al. (2014) described factors that determine the intention of improving natural grassland by fertilization or introduction of new forage species in Brazil. Donati et al. (2015) focused on the acceptance of two different strategies of land use in durum wheat farms in Southern Italy. Yazdanpanah et al. (2014) analyzed farmers' behavior about water conservation strategies in Iran. Wauters et al. (2010) compared factors affecting the adoption of three agricultural practices to prevent erosion – buffer strips, cover crops and reduced tillage in Belgium. Bijttebier et al. (2018) investigated farmers' reasons behind the implementation or not of non-inversion tillage in four European countries. The present work differs from most of the literature cited as it compares six different agricultural practices at a time, and because it attempts to analyze in detail drivers and barriers, also through the separate analysis of the two components (beliefs and evaluations) that constitute outcomes, referents and control factors.

The aim of the work described in this paper was to identify farmers' barriers and drivers towards the adoption of a number of practices that are expected to improve sustainability of crop management on dairy farms located in northern Italy: incorporation of crop residue, green manure, crop rotation with grass meadows, crop rotation with legume meadows, sprinkler or drip irrigation, and adoption of a nutrient management plan. We surveyed farmers' opinion using the theory of planned behaviour as a framework, through a mixed approach of qualitative interviews and a detailed quantitative questionnaire. In this paper, we decided not to analyse the psychological gap between intention and behaviour, nor to explore the external factors that condition the farmer's intention, but rather to analyse separately the two components that constitute an outcome, referent or control factor in the theory.

This work contributes to improve knowledge in two ways. First, it sheds new light on the reasons why farmers are reluctant in adopting environmental-friendly practices. Second, it provides a knowledge basis and guidance for an effective policy-making to boost the diffusion of good practices among dairy farmers in the critical area of the Po plain.

2. Materials and methods

2.1 The study area

We concentrated on dairy farms lying in the Po plain in northern Italy. The Po plain is a 2.7 million of hectares-wide intensively cultivated area where more than 85% of Italian milk is produced (www.ompz.it). The average number of dairy cows per farm is 106, with a stocking rate of 2.62 cows per hectare (Pieri, 2016). Cows' diet is often based on silage maize, apart from areas where silage maize is banned to produce Parmigiano Reggiano cheese (Mantovi et al., 2015). Maize is in fact the most productive forage crop in this area, highly fertilized and irrigated. Italian ryegrass is frequently grown in winter between two maize crops, to be ensiled and used as feed (Zavattaro et al., 2012).

2.2 General strategy

We applied a sequential mixed method that involves a qualitative technique first, and a quantitative technique subsequently (Creswell and Clark, 2011). The qualitative step involved semi-structured interviews with a small number of farmers, to identify the major outcomes, referents and control factors for each BMP studied. The definitions of the BMPs are reported in Table 1. Based on the result of this preliminary step, we conducted a quantitative large scale survey as a second step of the mixed method. The interview methodology was already described by Bechini et al. (2015), who reported results from the same survey discussed here but focused only on the soil incorporation of crop residues, in a wider set of farm types.

Table 1

2.3 Preliminary semi-structured interviews

We carried out preliminary interviews with seven dairy farmers in the study area during November 2012 - March 2013. During the interviews, we asked each farmer to list the outcomes that she/he would expect to happen if the BMPs were applied in her/his farm, the control factors that encourage (or make it more difficult) the application of the BMP on the farm, and the persons (referents) who stimulate or hamper the adoption of the BMP. Each semi-structured interview lasted about 45 min. During the interview we took care not to influence the farmer; thus, we avoided suggesting answers to the questions that we had put.

2.4 Preparation and test of the questionnaire

The questionnaire for the survey was prepared based on the results of preliminary semi-structured interviews. Pooled together, the answers given by farmers during the preliminary interviews consisted of a long list of outcomes, referents and control factors for each BMP. We decided to include in the questionnaire only the outcomes, referents and control factors that were mentioned more than once as they were considered to be more important than those mentioned only once. The list of outcomes, referents and control factors retained in the questionnaire is reported in Table 2.

To quantify the beliefs associated with each of the outcomes, referents and control factors, we asked questions like those listed here (with examples of one outcome, one referent and one control factor for the adoption of green manure):

Outcomes. "Cultivating green manure increases soil organic matter; 1: not likely, 5: very likely" (**behavioural belief strength** of the outcome 'increased soil organic matter'). "What do you think about increased soil organic matter? 1: not desirable; 5: very desirable" (**outcome evaluation** of the outcome 'increased soil organic matter').

Referents. "Feed advisors think I should (or should not) cultivate green manure; 1: I should not; 5: I should" (**normative belief** for the referent 'feed advisors'). "I take into consideration the opinion of feed advisors; 1: not at all; 5: completely" (**motivation to comply** for the referent 'feed advisors').

Control factors. "My soils have a bad structure; 1: no; 5: yes" (**control strength** for the control factor 'bad soil structure'). "With a bad soil structure, it is very difficult (or very easy) to cultivate green manure: 1: very difficult; 5: very easy" (**control power** for the control factor 'bad soil structure').

The questions asked can therefore be divided into "evaluation questions" (to quantify outcome evaluation, normative belief and control power) and "belief or strength questions" (to quantify behavioural belief strength, motivation to comply and control strength) (Figure 1).

The questionnaire also included an introductory section with general questions about the interviewee (e.g. age and sex), the farm (e.g. localisation, utilised agricultural area, land use, soil texture, tillage method, number of livestock heads), and information sources used (on a 1 to 5 scale). Finally, for each practice we included (i) questions whether the practice was adopted or not (and on which farm area), and (ii) three intention questions that represented the same concept with different wording (e.g. "I will cultivate green manure next year", "I will adopt green manure next year", and "Next year I have the intention to cultivate green manure"). The intention questions were randomised in the questionnaire, and were used to assess reliability of the measurement scale for intention.

In June 2013, before starting the survey, the questionnaire was tested with a few farmers to verify that all questions were correctly interpreted by the farmers.

Table 2

2.5 The survey

With the help of a large network of advisors we distributed the questionnaire to dairy farmers in the study area, during summer and autumn 2013. We received 92 completed questionnaires.

2.6 Data analysis

To identify if an outcome, a referent or a control factor could be considered a driver or a barrier by farmers, we followed this procedure, separately for each BMP.

We first calculated the combined effects for each outcome, referent and control factor by multiplying the strength question by the evaluation question diminished by three:

$$\textit{attitude} = \textit{behavioural belief strength} \times (\textit{outcome evaluation} - 3) \qquad [1]$$

$$\textit{subjective norm} = \textit{motivation to comply} \times (\textit{normative belief} - 3) \qquad [2]$$

$$\textit{perceived behavioural control} = \textit{control strength} \times (\textit{control power} - 3) \qquad [3]$$

The strongest score for a driver was then +10, the strongest score for a barrier was -10.

Second, we identified adopters as farmers who applied the practice on at least a field in their farms.

Third, we identified all the outcomes, referents and control factors for which the combined effect (attitude, subjective norm and perceived behavioural control) was not significantly different between adopters and non-adopters, that we distinguished using a Kruskal-Wallis test at $P<0.05$. The non-parametric test was used due to the non-normal distributions of the combined effects to be compared.

Fourth, for these outcomes, referents and control factors we identified drivers and barriers when they met two criteria simultaneously. For outcomes: the absolute value for attitude was higher than 3 (consistent combined effect) and the underlying behavioural belief strength was 3 or more (outcome very likely). For referents: both the absolute value for subjective norm (consistent combined effect) and its underlying motivation to comply (the interviewee wants to comply with the referent) were 3 or more. For control factors: both the absolute value for perceived behavioural control (consistent combined effect) and its underlying control strength (the control factor is strongly present at the interviewee's farm) were 3 or more. Drivers had a positive attitude, or subjective norm, or perceived behavioural control, while barriers had negative values. All criteria were evaluated separately for adopters and non-adopters when the two groups were significantly different (step 3). Figure 2 shows the rationale for these choices.

For each BMP, Cronbach's α (Cronbach, 1951) was calculated on the three intention questions to measure internal consistency of the answers. Nunnaly (1978), as reported by Reynaldo A. Santos (1999), has indicated 0.7 to be an acceptable value for α.

For the preparation of figures and tables, factors that influence the intention to adopt the BMPs were classified into four groups: Soil and environment, Financial issues, Cultivation technique and Social issues.

Figure 2

3. Results

3.1 Farm characteristics

Table 3 reports a selection of farm information declared by the farmer in the questionnaire. Farms were on average rather large (the mean farm size was 99 ha), were in the plain (97% of the farm area lay on flat or nearly flat soils), and used irrigation (in 95% of the cases). Soil organic matter content was rather good (3.3% on average). Livestock density (on average 1.9 dairy cows ha^{-1}) corresponds to a medium load. Maize was the most important crop in this type of farms (being the main component of cows' diet), followed by permanent grassland, winter cereals and alfalfa. These four crop types occupied on average 93% of the farm area. Most of the farm area lay on loam soils. Only 3% of the respondents produced organically. Farmers who answered the questionnaire were mostly males (97%). Based on these characteristics, we think our sample was not biased.

Table 3

Table 4

3.2 Adoption and intention to adopt best management practices

Table 4 reports summary statistics about the answers received. Almost all the farmers answered to the questions for the six best management practices. Adoption varied from 1% for green manure to 69% for crop residue incorporation. The intention (expressed on a 1-5 scale) was lowest for green manure and highest for the nutrient management plan; the Cronbach's α, indicating consistence between the three intention questions, was very high for all practices, with the exception of green manure.

Figure 3

Figure 4

Figure 5

3.3 Crop residue incorporation

Soil and environment. Farmers expected yields to increase and soil quality to improve (increase of soil organic matter and improvement of soil structure) following the incorporation of crop residues, as indicated by high behavioural belief strengths (Fig. 3a). These were highly desired outcomes, with high outcome evaluations (mean above 4, Fig. 3a). Therefore they acted as drivers (positive attitude of 4.61 - 6.20; Table 2a).

Financial issues. No barriers or drivers were identified here.

Cultivation technique. A strong barrier to crop residue incorporation was the increase of straw requirements at farm scale to be used as animal bedding. This outcome had a mean negative attitude of -4.21, significantly lower for non-adopters (-6.96) compared to adopters (-3.08) (Table 2a). The availability of adequate machinery was a strong driver: the mean perceived behavioural control was 4.92 (Table 2), significantly higher for adopters (5.65) than for non-adopters (3.19). Adopters had significantly more access to adequate machinery (i.e. with a residue-cutting tool on the combine harvest machine) and they were significantly more convinced than non-adopters that availability of adequate machinery would facilitate incorporation of crop residues (different control power: Fig. 3c).

Social issues. Compared to other practices, both referents (other farmers and advisors of companies selling production factors) had relatively high normative belief, in particular those in contact with adopters (Fig. 3d), meaning that they were perceived as being quite in favour of residue incorporation. However, the motivation to comply with these referents was not very high (Fig. 3d) and therefore the resulting subjective norm for adopters was only about 3 (Table 2a). The advisors of companies selling production factors were classified as a driver only for adopters. Non-adopters did not perceive that other farmers or the advisors were very much in favor or against residue incorporation and just like the adopters they also did not feel a high motivation to comply with these referents.

Summarizing, advantages of crop residue incorporation were well-known and acted as drivers. The main barrier was the reduction of straw available for the stable.

3.4 Green manure

Soil and environment. Farmers showed to know very well the advantages of cultivating green manure: improved soil structure, increased soil organic matter, reductions of N losses and weeds. These outcomes were considered as advantages (outcome evaluations higher than 4, Fig. 3a) and had an average behavioural belief strength higher than 3, thus they were classified as drivers.

Financial issues. The increase of cultivation costs (seed, seedbed preparation, sowing operations, and mechanical or chemical termination) was the strongest barrier to the adoption of green manure (negative attitude of -7.17: Table 2b), due to the fact that a non-desirable cost increase (very low outcome evaluation) was expected (high behavioural belief strength) (Fig. 3b).

Cultivation technique. The outcome "less inorganic fertiliser used" (Fig. 3c) was considered as a driver (Table 2b) because it was perceived both as very likely (3.96) and desirable (4.20; Fig. 3c). The expected lower self-production of forages (Fig. 3c), due to catch crop occupying the soil in the winter instead of winter forages like Italian ryegrass and wheat, was instead a barrier (Table 1b).

Social issues. None of the referents listed for this BMP had a normative belief higher than 2.5 (Fig. 3d), showing that the entire community surrounding the respondents is reluctant to suggest this practice (Fig. 3d). Feed advisors acted as the strongest barrier among referents, with a subjective norm of -4.03 (Table 2b), followed by other farmers with -3.60, which also exerted the highest motivation to comply.

Summing up, green manure was considered a valuable but unsuitable practice in dairy farms.

3.5 Rotation with grass meadows

Soil and environment. The soil-related driver for introducing grass meadows in rotation was the improvement of soil structure (mean attitude of 5.89; Table 2c), an outcome which was both desirable and likely (Fig. 4a).

Financial issues. No drivers or barriers were identified here.

Cultivation technique. Farmers know the advantages of introducing grass meadows in rotation. There are several expected outcomes for which the attitude was positive, and which therefore acted as drivers (Fig. 4c): less herbicide and insecticide needed (mean attitude 5.00 and 5.01), improved ration for dairy cows (4.88), and better distribution of labour peaks (4.33). All these outcomes were characterised by high desirability (mean outcome evaluation higher than 4) and were considered to occur likely (behavioural belief strength was on average above 3.5). Higher amount of irrigation water requested for grass meadows, compared to other crops, was a barrier for non-adopters (mean behavioural belief strength of 3.11) and gave rise to a moderately negative attitude (Table 2c).

Social issues. Three referents (other farmers, advisors of companies selling production factors and feed advisors) had a subjective norm close to zero, and therefore they acted neither as a driver nor as a barrier. However, as seen in other BMPs, normative beliefs and subjective norms were significantly higher for adopters compared to non-adopters, indicating that referents surrounding adopters are more insisting on grass meadows cultivation compared to those in touch with non-adopters.

In short, benefits were evident for both adopters and non-adopters, but no clear barriers were found. However, prices of alternative forages could play a role, as well as high irrigation water needs.

3.6 Rotation with legume meadows

Soil and environment. Most of the outcomes for legume meadows had very high behavioural belief strengths and outcome evaluations (Fig. 4a), and therefore very high attitudes (Table 2d). This means that advantages of cultivating legumes (e.g. improvement of soil fertility and soil structure, and increased crop yields) are well known by farmers, are expected to occur, and therefore act as drivers. Diversity of forage production, high forage productivity and improved soil structure were significantly considered more important (outcome evaluation) by adopters than by non-adopters.

Financial issues. Farmers expected that legume meadows would allow to reduce the cost of protein in the ration, compared to buying it (Fig. 4b); this outcome worked as a driver for all respondents (Table 2d). This is confirmed by the fact that high cost of soybean acted as a driver towards inclusion of legume meadows in rotation (Table 2d).

Moreover, all farmers expected that forage from legume meadows would increase milk production (driver; Table 2d).

Cultivation techniques. For adopters, the expertise to cultivate alfalfa – the most common legume used for meadows – was very important (control power of 4.31; Fig. 4c), and was available on farm (control strength of 4.64; Fig. 4c); this made it a driver for adopting legume meadows. Moreover, the expected better distribution of labour peaks obtained with legume meadows acted as a driver (Table 2d). The above-mentioned improvement of soil fertility was also recognized to lead to a reduction of fertiliser use for the following crop (Fig. 4c), an outcome which was clearly a driver for all respondents (Table 2d).

Social issues. For adopters, the referents most convinced about adoption of legume meadows were the advisors of producers associations and feed advisors, as shown by the normative belief (Fig. 4d). Also due to high motivation to comply with them, these referents were the ones with the highest subjective norm (Table 2d), that made them a driver for adopters. Other referents (other farmers and advisors of companies selling production factors) had subjective norms lower than 1 (Table 2d).

In brief, several drivers of various domains and no barriers were identified for this practice.

3.7 Sprinkler and drip irrigation

Soil and environment. As indicated by high behavioural belief strengths (Fig. 5a), farmers were aware of the advantages of sprinkler and drip irrigation compared to the widely used surface irrigation: less water consumed, with higher use efficiency, no crop water stress and higher yield, lower waterlogging and soil compaction. All these outcomes were classified as drivers and were characterised by positive attitudes (> 4; Table 2e).

Financial issues. These irrigation systems require substantial investments, which represent a barrier to adoption. This was clearly testified by the negative attitude of -6.81 for the outcome "higher costs" (Table 2e), which were considered rather likely (behavioural belief strength of 3.66) and completely undesired (outcome evaluation of 1.14; Fig. 5b). No significant differences existed between adopters and non-adopters.

Cultivation technique. Compared to surface irrigation, a lower diesel consumption (drip irrigation) and a higher diesel consumption (sprinkler irrigation) were identified as a driver and a barrier, respectively (Table 2e; Fig. 5c). The higher work required for utilizing self-retracting hose reel was identified as a barrier only by non-adopters (Table 2e).

Social issues. Family members were identified as a driver (only for adopters).

Summarizing, benefits of this BMP are well known, for both adopters and non-adopters; the largest barriers are related to costs.

3.8 Nutrient management plan

Soil and environment. In farmers' opinion, the nutrient management plan has two important advantages: it allows to better valorise livestock manure and to use the proper amount of fertilisers (Fig. 5a). These were two drivers.

Financial issues. The expected reduction of fertiliser costs was another driver for the adoption of nutrient management plan (Table 2f), while the costs for soil analysis did not act as a barrier (attitude of -2.44, Table 2f).

Cultivation techniques. Farmers were well aware of the advantages of adopting a nutrient management plan, not only in terms of crop production (higher yield stability), but also for its effects on livestock (higher forage quality, higher livestock health, improved milk quality). All these outcomes were classified as drivers (Table 2f).

Social issues and legislation. Family members, advisors of producers' associations and feed advisors were identified as drivers for adopters. They were aware of the importance of adopting nutrient management plan (high normative belief). Moreover, their opinion was important for the respondents (high motivation to comply, in particular for adopters).

In synthesis, only drivers were detected also for this practice.

4. Discussion and Conclusions

4.1 Adoption, drivers and barriers

Among the observed BMPs, the most diffused according to adoption scores were crop residue incorporation and nutrient management plan, while green manure was not used and will not be used (no intention).

The extremely low adoption of green manures was bewildering. A low organic matter content and bad structure did not act as drivers for adopting green manure. Likely, low soil organic matter and a bad soil structure are not an issue in these dairy farms (as testified by low control strength in Fig. 3a). Soils have been historically and are presently amended with animal manure produced at the farm, and this contributes to maintain or increase the soil organic matter (Zavattaro et al., 2017). In farmers' opinion, the access to economic incentives was low for green manure. If available, however, incentives do not appear to be conclusive, because their control power was 2.87 only. Therefore it is not expected that they would increase adoption substantially. Moreover, a cover crop during winter (in between two maize crops) competes with a winter forage crop (like Italian ryegrass or triticale) on the same soil, which could be an important barrier for this practice, specific to dairy farms.

As far as all practices are concerned altogether, we found that explicit or implicit costs were frequently advocated as barriers, while among the most important drivers we found environmental factors and sustainability issues: soil structure, soil organic matter, soil health, N losses, use of pesticides or herbicides. This means that Italian dairy farmers not only have financial and management goals, but are also keen on sustainability issues and consider soil an important resource. Furthermore, they are well aware of the expected effects of these practices on soil quality. The importance of the attitude towards environmental issues, such as plant biodiversity, was also identified as a strong differential determinant among Irish dairy farmers, as discussed by Power et al. (2013). Another important topic that was touched with the questionnaires is knowledge. The expertise to grow alfalfa was a driver for legume meadows cultivation for adopters. It was also of great importance for them to have alfalfa cultivated in the same area (control power of 4.09; Fig. 4c), which made it a driver for them, probably because this allowed to have more knowledgeable farmers around. In other cases knowledge played a less clear role. For instance, farmers thought they knew fairly well the benefits of crop residue incorporation; therefore this factor did not act as a barrier or a driver either.

The number of barriers was markedly smaller than the number of drivers. For example, no barriers were identified for rotations with legume meadows or grass meadows, and although farmers were well aware of their benefits, adoption was limited. A similar situation occurred for the nutrient management plan. We have several hypotheses to explain why only a few barriers were identified in our study.

One hypothesis is that semi-structured interviews by which we defined questions for the questionnaires, could have failed in identifying some barriers, for example because of an insufficient number of farmers involved, or because farmers were not sufficiently representative. Actually, outcomes, referents or factors mentioned as barriers in the semi-structured interviews did not end up to be identified as barriers in the questionnaires.

Secondly, data analysis could have failed to identify barriers of local nature, because we did not analyse farmers' answers separately by region or by farm characteristics. For example, in the case of crop residue incorporation, the increase of straw requirements was considered significantly less likely by adopters. On the other hand, adopters considered an increase of straw requirements to be less undesirable. Differences between adopters and non-adopters might be linked to different housing systems, with the adopters requiring less or no straw in the stable. Moreover, costs might be more important for a certain farm size, while the lack of economic incentives, depending on regional funding, might be more relevant in a region compared to another. In other cases it is more difficult to make a hypothesis of what can differentiate adopters from non-adopters: for sprinkler and drip irrigation, no significant differences were observed between adopters and non-adopters for behavioural belief strengths, outcome evaluations and attitudes of the outcomes identified as drivers (Table 2e). This suggests that adopters and non-adopters of these irrigation methods operate in environments and farming systems that are similar for what concerns the adoption of this practice, or at least that their perceptions and expectations are similar.

Thirdly, missing barriers might be linked to elements not included in the Theory of Planned Behaviour (e.g. self-identify, moral obligation, habit), as stated by some researchers (e.g. Burton, 2004; Yazdanpanah et al., 2014). However, this approach remains a good starting point to explain people's behaviour (Beedell and Rehman, 2000).

In general, and apart from the case of green manure, referents did not emerge as the strongest drivers or barriers. However, they made a significant difference between adopters and non-adopters. In particular, the normative belief of referents surrounding adopters in many cases was significantly higher compared to non-adopters, while the motivation to comply was not different. This means that most referents in touch with adopters were significantly more convinced that the respondents should adopt the BMP (normative belief) compared to the same referents that were in touch with non-adopters. Because the motivation to comply with these referents was in most cases not significantly different between adopters and non-adopters, when we found a significantly different subjective norm, this did not depend on how these referents were rated by respondents, but on what the respondents thought these referents expected from them. In addition to that, the lack of independent and trustable advisors is felt as a problem by the farmers' community.

Finally, legislation never acted as a driver (or a barrier) to adoption, and was mentioned only regarding nutrient management plan.

4.2 Policies to increase adoption

These results give hints on how policy makers could promote the adoption of BMPs. To be effective, policies and programs that promote the diffusion of good practices, should recognise farmers' beliefs that are associated with the practices, and how these beliefs may impact on their decisions (Fielding et al., 2005). Wauters et al. (2010), Martinovska Stojcheska et al. (2016) and Donati et al. (2015) in Belgium, Western Balkan countries and Italy, respectively, concluded that trying to solve technical or economic difficulties might be ineffective when farmers' attitudes remain negative. Therefore, they suggested that a policy action directed to people could be more cogent than economic incentives or other types of support directed to solve technical problems. Outside Europe other tools such as a normative action, and economic subsidies were identified as the most effective policies, as attitude was not the main driver (Poppenborg and Koellern, 2013 in South Korea; Borges and Oude Lansink, 2015, in Brazil; Yazdanpanah et al., 2014, in Iran; Hyland et al., 2018 in Ireland).

In Italian dairy farms, the creation of a favourable environment of referents could be of help, by educating advisors and promoting the communication among farmers. This action should be primarily focused on referents with whom farmers have a high motivation to comply, e.g. feed advisors, and through the reinforcement of local favourable communities, because endorsement from other farmers is certainly a strong determinant to farmers' choice (Fielding et al., 2005), as seen also in our study. In particular, as Beedell and Rehman (2000) pointed out, farmers who most need advice and training often are the least likely to seek it voluntarily, and therefore building up a peer community favourable to the introduction of best practices could be the most efficient way to involve them, starting from potential agents of change such as village leaders or information brokers (Martinovska Stojcheska et al., 2016). Family members are also important referents, this suggesting a generational change could increase adoption when older family members are reluctant to innovations.

Economic incentives could make a difference for some BMPs where costs are a barrier, such as green manure and sprinkler and drip irrigation methods. As both adopters and non-adopters are well aware of the benefits of BMPs, extension services should not only focus on raising awareness on the benefits for soil, environment, and cultivation techniques. They should focus more on the cost/benefit relationship, and on giving technical instructions for the optimal application of the BMP. From our direct experience, this is very important for cover crop cultivation.

Regarding barriers related to costs, the question arises if costs are really greater than benefits or the non-adopters are not aware that benefits are larger than costs. If the latter, extension and maybe additional applied research should gather data on the cost/benefit and distribute these figures to non-adopters and to those referents for whom they have a high motivation to comply. This involves also gathering data on the financial benefits of improved soil quality, for example. Further local-oriented research is needed in this field to propose tailor-made solutions in promoting the use of good practices.

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Table 1. Definitions of the BMPs analysed in this study. Definitions were agreed among the CATCH-C project working group (Spiegel et al., 2014) and were explained to farmers before the interview.

Best Management Practice (BMP)	Definition
Crop residue incorporation	Crop residue is the fraction of aboveground biomass that is not harvested as a useful product, i.e. the straw of winter cereals or the stalks of maize/sunflower. This is different than the stubble, which is normally left on the field. This BMP involves leaving crop residues on the field after harvesting the useful product. For simplicity, we speak about 'crop residue incorporation' also in the case of no-tillage, when residues are left on the soil surface. The alternative to residue incorporation is residue removal.
Green manure	Green manuring consists in sowing and growing a catch or cover crop, which is not harvested but completely buried (or left on the soil in case of no-tillage) before sowing the following cash crop. Incorporation of crop residue in the soil is not classified as green manuring. The alternative to green manuring is leaving the soil bare during the period between two cash crops, normally during the fall and the winter.
Rotation with grass meadows	The rotation of crops involves the variation, from one production cycle to the next one, of the cultivated species in a given field. The new crop that is inserted in this BMP (grass meadow) is cultivated for more than one year. The grass meadow is mostly composed of forage crops of the *Poaceae* family (with no or few species of the *Fabaceae* family).
Rotation with legume meadows	Rotation with legume crops involves the variation of the cultivated species in a field over time, by inserting legume meadows, which remain in place for more than one year. The legume meadow that is usually practiced in dairy farms in northern Italy is alfalfa (*Medicago sativa* L.).
Sprinkler and drip irrigation	Sprinkler and drip irrigation systems apply water to the field with high efficiency by delivering small water drops, either from the air (in the case of sprinkler irrigation: self retracting hose reel and pivot) or from above or below the soil surface (in the case of drip irrigation). These methods were chosen due to the increasing interest in irrigation methods that can save water, compared to the widely used surface methods.
Nutrient management plan	A nutrient management plan is a tool allowing to define the amount of nutrients to be applied, its splitting (dates and amounts), and the type of mineral and organic fertilisers to

	be used. The calculation is based on expected yield, yield quality, soil properties, climate, and rotation.

Table 2. Mean values for attitudes, subjective norms, and perceived behavioural controls of outcomes, referents, and control factors towards the dairy farms farm typology, as surveyed among Italian farmers in 2013.

The meaning of letters in the last column are as follows:

"a": The first question (behavioural belief strength, motivation to comply, or control strength) is significantly different between A (adopters) and NA (non-adopters) according to a Kruskal-Wallis test at P<0.05.

"b": The second question (outcome evaluation, normative belief, or control power) is significantly different between A and NA, according to a Kruskal-Wallis test at P < 0.05.

"c": The combined effect (attitude, subjective norm, or perceived behavioural control) is significantly different between A and NA, according to a Kruskal-Wallis test at P < 0.05. If this is the case, attitudes, subjective norms, and perceived behavioural controls are provided both as an average for the whole sample, and separately for A and NA.

Attitudes, normative beliefs, and perceived behavioural controls for each BMP	**Type of answer**	**Driver or Barrier**	**Attitude / Subjective norm / Perceived behavioural control**
Crop residues incorporation			
Soil and environment			
Improved soil structure	Outcome	Driver	6.20
Increased crop yield	Outcome	Driver	5.60
Increased soil organic matter	Outcome	Driver	4.61
Reduced weeds and fungi in following crop	Outcome		2.56
Financial			

Access to market of winter cereals straw	Control factor		1.22 b
Cultivation technique			
Availability of adequate machinery	Control factor	Driver	4.92 abc (5.65 A; 3.19 NA)
Lack of knowledge of advantages of incorporation	Control factor		-0.03 bc (0.65 A; -1.65 NA)
Increase straw requirements at farm scale	Outcome	Barrier	-4.21 abc (-3.08 A; -6.96 NA)
Social			
Advisors of companies selling production factors	Referent	Driver for adopters	2.07 bc (3.17 A; -0.48 NA)
Other farmers	Referent		1.87 bc (2.90 A; -0.52 NA)
Green manure			
Soil and environment			
Improved soil structure	Outcome	Driver	6.10
Increased soil organic matter	Outcome	Driver	5.76
Less weeds	Outcome	Driver	5.23

Less nitrogen losses from soil	Outcome	Driver	4.52
Low soil organic matter	Control factor		0.79
Bad soil structure	Control factor		0.61
Financial			
Access to economic incentives for green manure	Control factor		-0.30 a
Cost increase	Outcome	Barrier	-7.17 b
Cultivation technique			
Less inorganic fertiliser used	Outcome	Driver	4.81
Availability of livestock manure	Control factor		-2.77
Lower self-production of forage	Outcome	Barrier	-4.23
Social			
Contractors	Referent		-1.51 b
Advisors of companies selling production factors	Referent		-1.65

Advisors of professional organisations	Referent		-1.73
Other farmers	Referent	Barrier	-3.60
Feed advisors	Referent	Barrier	-4.03
Rotation with grass meadows			
Soil and environment			
Improved soil structure	Outcome	Driver	5.89
Scarce availability of irrigation water in my farm	Control factor		-0.71 bc (0.32 A; -1.64 NA)
Meadows have a lower N uptake compared to other crops, and thus limit the possibility to apply livestock manure	Outcome		-0.96
Financial			
High forage prices	Control factor		2.45
Economic incentives for cultivating grass meadows	Control factor		1.81 bc (2.61 A; 1.09 NA)
High selling price of maize	Control factor		-2.07 a
Cost for meadow cultivation	Outcome		-2.22

Cultivation technique			
Less insecticides needed	Outcome	Driver	5.01
Less herbicides needed	Outcome	Driver	5.00
Improves ration of dairy cows	Outcome	Driver	4.88
Better distribution of labour peaks in the farm	Outcome	Driver	4.33
High irrigation amount needed	Outcome	Barrier for non-adopters	-2.69 c (-1.78 A; -3.55 NA)
Social			
Other farmers	Referent		0.83 bc (2.29 A; -0.50 NA)
Feed advisors	Referent		0.75 bc (2.68 A; -1.00 NA)
Advisors of companies selling production factors	Referent		0.13 bc (1.92 A; -1.45 NA)
Rotation with legume meadows			
Soil and environment			
Increased crop yield	Outcome	Driver	7.44 b

Increased soil fertility	Outcome	Driver	6.74
Improved soil structure	Outcome	Driver	6.22 c (6.93 A; 5.32 NA)
Less weeds	Outcome	Driver	5.97
Diversity of forage production	Outcome	Driver	5.77 abc (7.09 A; 4.11 NA)
High forage production	Outcome	Driver	5.69 c (6.38 A; 4.83 NA)
Reduction of insects and pathogens in following crop	Outcome	Driver	4.41
Financial			
Increased milk production	Outcome	Driver	6.41 ac (7.31 A; 5.26 NA)
Reduced cost of protein for the ration, compared to buying it	Outcome	Driver	5.91 abc (7.20 A; 4.31 NA)
High cost of soybean	Control factor	Driver	4.34 bc (6.07 A; 2.15 NA)
Cultivation technique			
Reduction of fertilisers in following crop	Outcome	Driver	6.02
Better distribution of labour peaks in the farm	Outcome	Driver	4.24

Expertise to cultivate alfalfa	Control factor	Driver for adopters	4.15 abc (6.22 A; 1.49 NA)
Widespread cultivation of alfalfa in my area	Control factor	Driver for adopters	2.35 abc (4.00 A; 0.23 NA)
Scarce irrigation water availability	Control factor		1.03 bc (1.64 A; 0.24 NA)
Social			
Feed advisors	Referent	Driver for adopters	2.83 bc (4.05 A; 1.27 NA)
Advisors of producers associations	Referent	Driver for adopters	1.93 bc (3.26 A; 0.24 NA)
Advisors of companies selling production factors	Referent		0.97 bc (1.95 A; -0.27 NA)
Other farmers	Referent		0.87 bc (1.79 A; -0.33 NA)
Sprinkler and drip irrigation			
Soil and environment			
Higher water use efficiency	Outcome	Driver	6.05 a
Higher crop yield	Outcome	Driver	5.76
No crop water stress	Outcome	Driver	5.34

Less waterlogging	Outcome	Driver	5.13
Less water consumption	Outcome	Driver	4.84
Less soil compaction	Outcome	Driver	4.29
Less insects (sprinkler)	Outcome		2.12
High water availability	Control factor		1.41 c (2.59 A; 0.26 NA)
Sandy soils	Control factor		0.80 bc (1.90 A; -0.26 NA)
Financial			
Higher costs	Outcome	Barrier	-6.81
Cultivation technique			
Lower diesel consumption (drip irrigation)	Outcome	Driver	5.10
Shorter work in case of pivot	Outcome	Driver	3.30
Small field size	Control factor		-0.76
Longer work for self-retracting hose reel	Outcome	Barrier for non-adopters	-2.69 c (-1.64 A; -3.72 NA)

Higher diesel consumption (sprinkler)	Outcome	Barrier	-4.30
Social			
Sellers of irrigation systems	Referent		2.15 bc (3.00 A; 1.30 NA)
Advisors of companies selling production factors	Referent		0.84 bc (2.68 A; -0.79 NA)
Advisors of irrigation consortium	Referent		0.76 bc (2.00 A; -0.49 NA)
Other farmers	Referent		0.37 abc (2.39 A; -1.42 NA)
My family members	Referent	Driver for adopters	0.12 bc (3.05 A; -2.67 NA)
Feed advisor	Referent		-0.01 bc (2.03 A; -1.81 NA)
Nutrient management plan			
Soil and environment			
Valorisation of livestock manure	Outcome	Driver	6.62 a
Use of the proper fertiliser amount	Outcome	Driver	6.47
Scarce information on the value of livestock manure	Control factor		-1.73

Financial			
Reduction of fertiliser costs	Outcome	Driver	6.07
Low fertiliser prices	Control factor		0.28
Increase of costs due to soil testing	Outcome		-2.44
Cultivation technique			
Better forage quality	Outcome	Driver	5.94
Higher yield stability	Outcome	Driver	5.92
Better livestock health	Outcome	Driver	5.73
Improved milk quality	Outcome	Driver	5.40
Social			
Advisors of producers associations	Referent	Driver for adopters	3.94 c (4.58 A; 2.29 NA)
My family members	Referent	Driver for adopters	3.32 bc (4.21 A; 1.24 NA)
Feed advisors	Referent	Driver for adopters	2.99 bc (3.98 A; 0.67 NA)

Advisors of companies selling production factors	Referent	2.93
Other farmers	Referent	1.78 bc (2.55 A; 0.04 NA)
Lack of an independent service for fertilisation advice	Control factor	-1.00
Legislation		
Legislative limitations to the amount of livestock manure that can be applied	Control factor	2.48

Table 3. Statistics about farm characteristics declared by the farmer in the questionnaire (n = 92).

	Units	Average	Standard deviation	20th percentile	80th percentile
Farmer age	yr	47	11	38	56
Farm area	ha	99	115	30	126
Bovine heads	heads ha^{-1}	3.5	1.8	2.0	5.2
Dairy cows	cows ha^{-1}	1.9	1.1	1.0	2.9
Land use					
Maize	% farm area	53	23	37	72
Permanent grassland and pasture	% farm area	23	22	1	39
Winter cereals	% farm area	9	11	0	15
Alfalfa	% farm area	8	20	0	10
Legume grains	% farm area	2	5	0	0
Annual grassland	% farm area	2	7	0	3
Other crops	% farm area	2	1	0	0
Tree crops	% farm area	1	6	0	0
Soil texture					
Sandy soils	% farm area	10	23	0	15
Loamy soils	% farm area	72	35	40	100
Clay soils	% farm area	18	29	0	40
Soil organic matter	%	3.3	1.2	2.0	4.6

Table 4. Adoption and intention for six best management practices of dairy farmers in northern Italy.

Best management practice	**Number of interviewees**	**Number of adopters**	**Intention (average and standard deviation)** [a]	**Cronbach's α**
Crop residue incorporation	91	63 (69%)	3.36 (1.62)	0.97
Green manure	91	1 (1%)	1.11 (0.35)	0.71
Rotation with grass meadows	92	42 (46%)	2.83 (1.72)	0.97
Rotation with legume meadows	92	47 (51%)	3.42 (1.65)	0.96
Sprinkler and drip irrigation	92	49 (53%)	2.64 (1.75)	0.97
Nutrient management plan	91	58 (64%)	3.88 (1.45)	0.98

[a] Intention is expressed on a 1-5 scale.

Figure 1. Theory of planned behaviour (adapted from Ajzen, 1991)

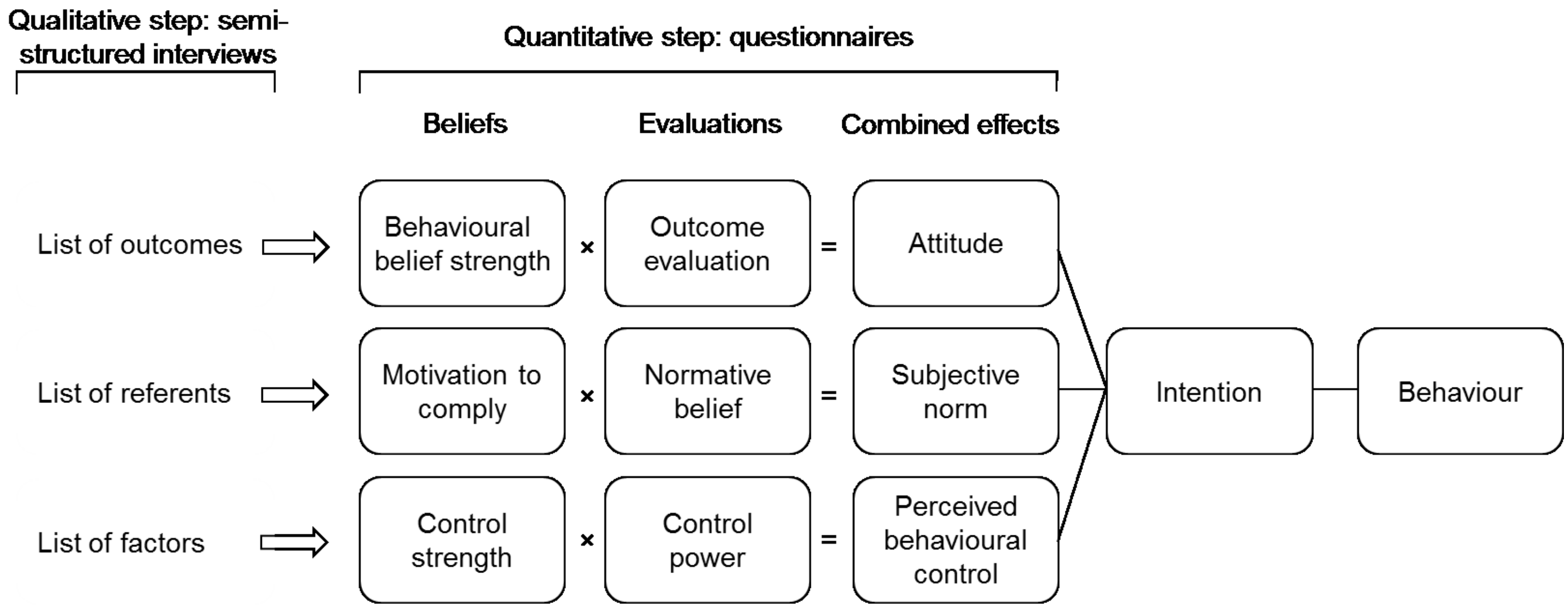


Figure 2. Criteria used to identify drivers and barriers: the absolute value for attitude / subjective norm / perceived behavioural control was higher than 3 (consistent combined effect) and the underlying behavioural belief strength / motivation to comply / control strength was higher than 3. Drivers are represented in green, and barriers in orange.

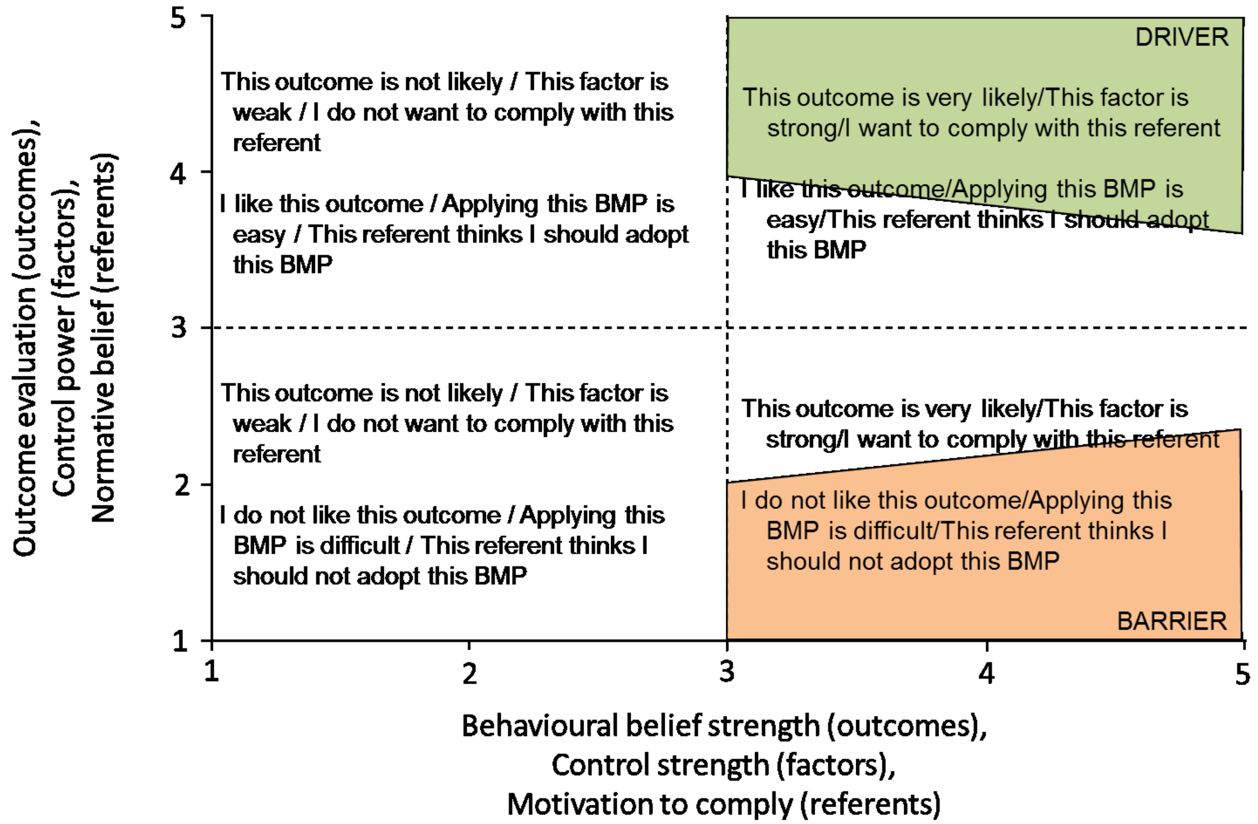
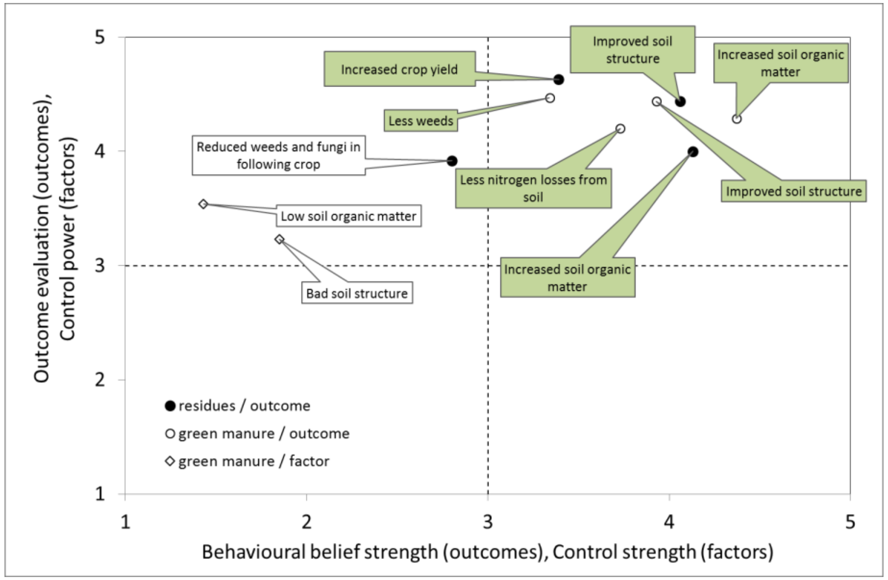
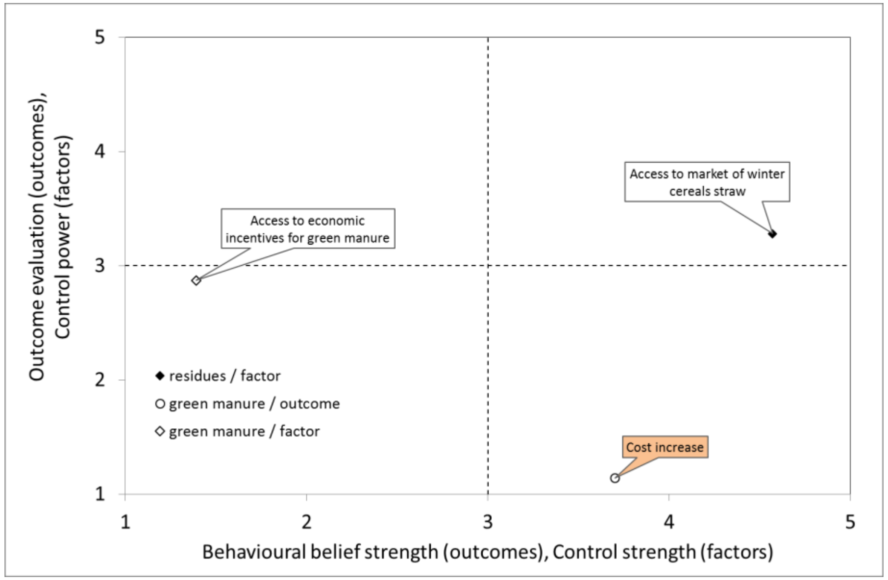


Figure 3. Crop residue incorporation and green manure: average of strength questions (X-axis) and evaluation questions (Y-axis) related to (a) soil and environment, (b) financial issues, (c) cultivation technique and (d) social issues. When the combined effect is significantly different between adopters and non-adopters, the symbols are presented separately for adopters and non-adopters in the graph. Drivers are represented in green, and barriers in orange.

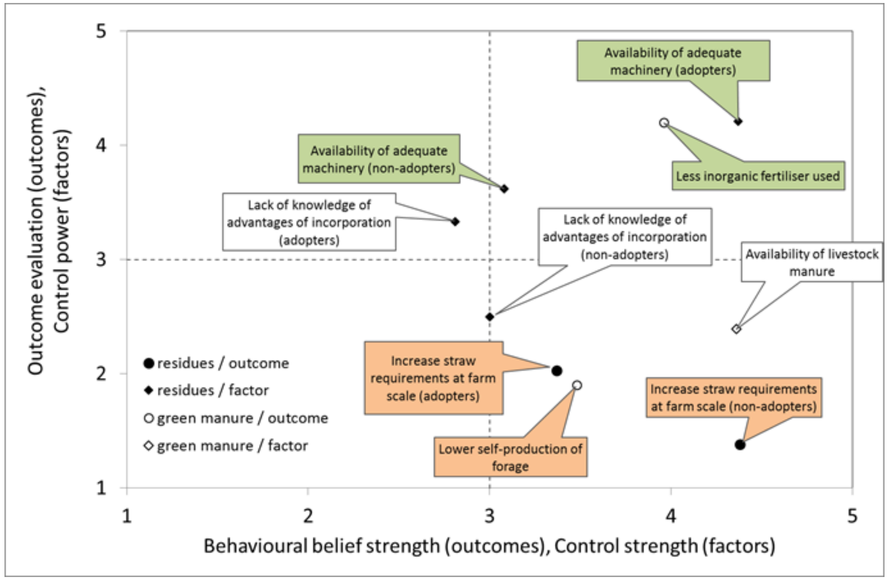
a



b



c


Availability of adequate machinery (adopters)
Availability of adequate machinery (non-adopters)
Less inorganic fertiliser used
Lack of knowledge of advantages of incorporation (adopters)
Lack of knowledge of advantages of incorporation (non-adopters)
Availability of livestock manure
Increase straw requirements at farm scale (adopters)
Increase straw requirements at farm scale (non-adopters)
Lower self-production of forage
residues / outcome
residues / factor
green manure / outcome
green manure / factor
Outcome evaluation (outcomes), Control power (factors)
Behavioural belief strength (outcomes), Control strength (factors)
1
2
3
4
5

d

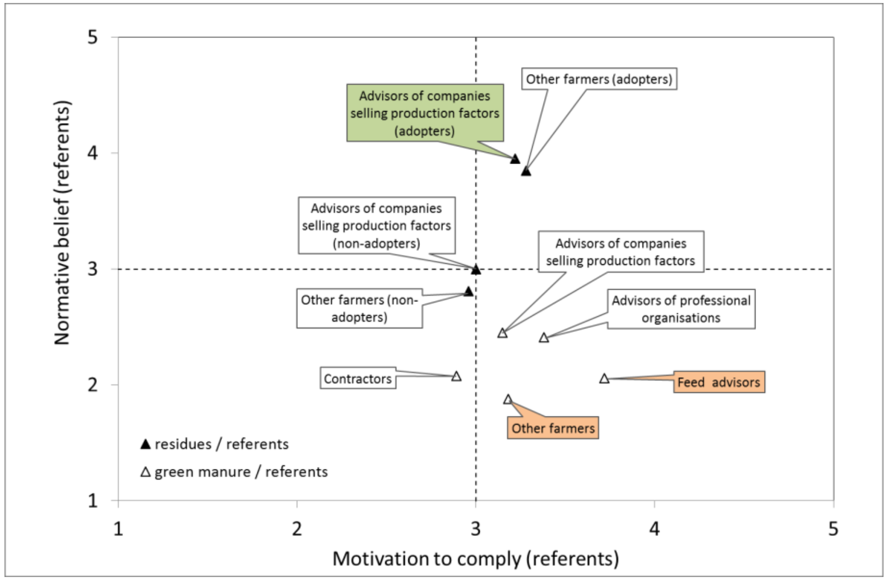
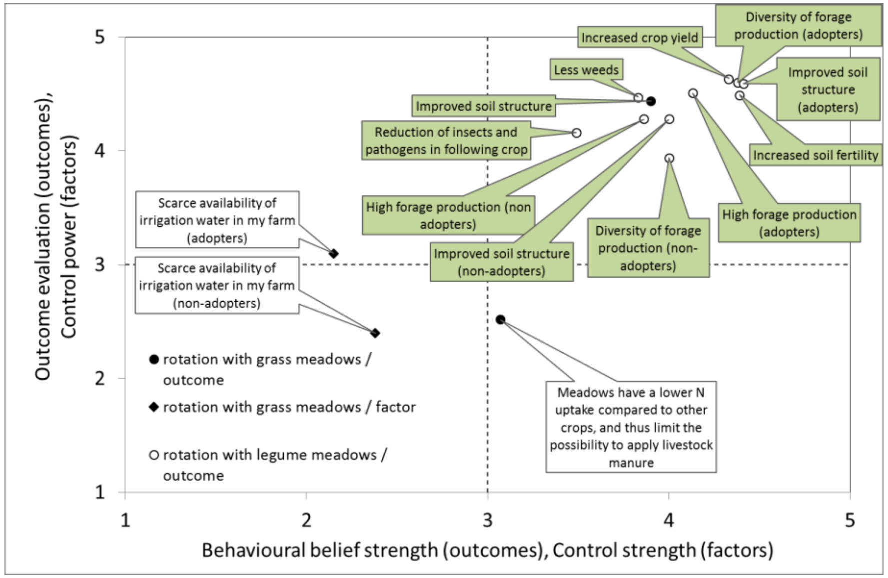
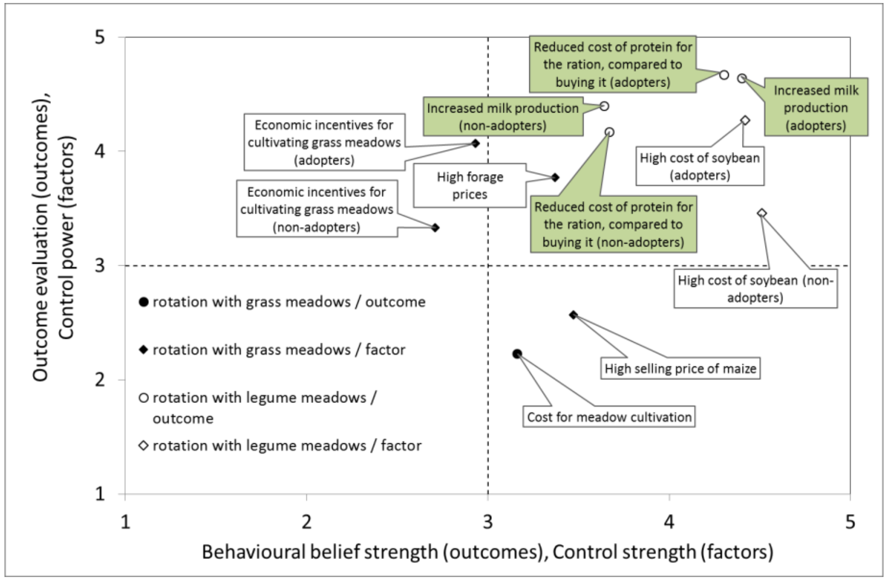

Other farmers (adopters)
Advisors of companies selling production factors (adopters)
Advisors of companies selling production factors (non-adopters)
Advisors of companies selling production factors
Other farmers (non-adopters)
Advisors of professional organisations
Contractors
Feed advisors
Other farmers
residues / referents
green manure / referents
Normative belief (referents)
Motivation to comply (referents)
1
2
3
4
5

Figure 4. Rotation with grass meadows, and rotation with legume meadows: average of first and second questions related to (a) soil and environment, (b) financial issues, (c) cultivation technique and (d) social issues. When the combined effect is significantly different between adopters and non-adopters, the symbols are presented separately for adopters and non-adopters in the graph. Drivers are represented in green, and barriers in orange.

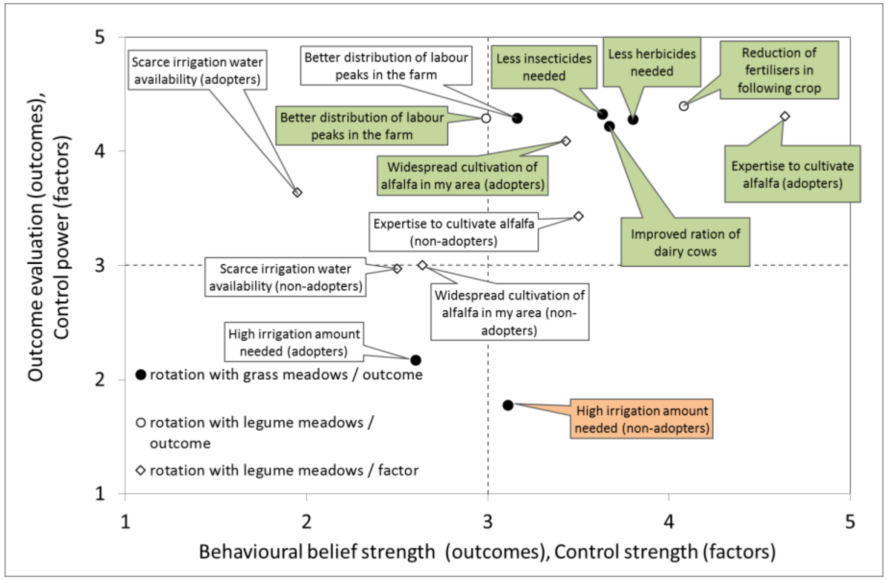
a



b



c


Outcome evaluation (outcomes), Control power (factors)
Behavioural belief strength (outcomes), Control strength (factors)
Scarce irrigation water availability (adopters)
Better distribution of labour peaks in the farm
Less insecticides needed
Less herbicides needed
Reduction of fertilisers in following crop
Better distribution of labour peaks in the farm
Widespread cultivation of alfalfa in my area (adopters)
Expertise to cultivate alfalfa (adopters)
Expertise to cultivate alfalfa (non-adopters)
Improved ration of dairy cows
Scarce irrigation water availability (non-adopters)
Widespread cultivation of alfalfa in my area (non-adopters)
High irrigation amount needed (adopters)
High irrigation amount needed (non-adopters)
● rotation with grass meadows / outcome
○ rotation with legume meadows / outcome
◇ rotation with legume meadows / factor

d

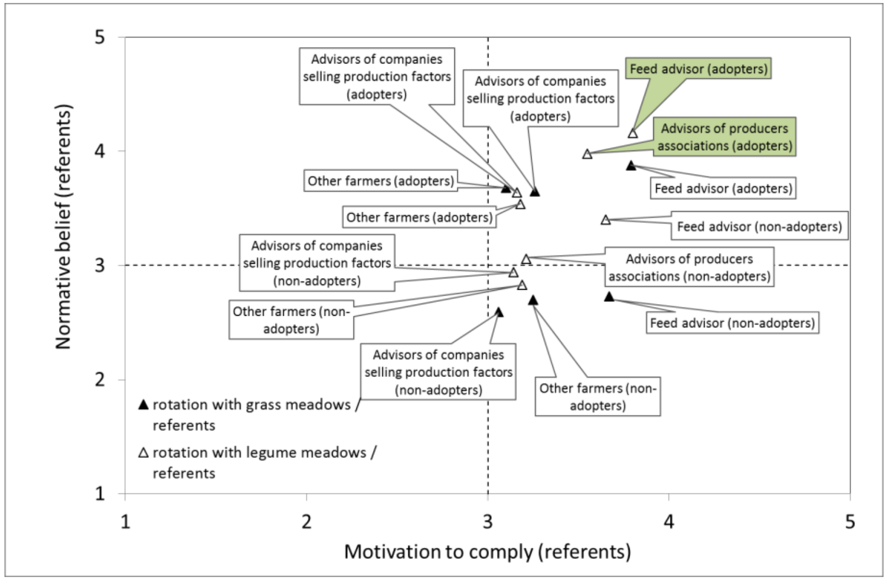
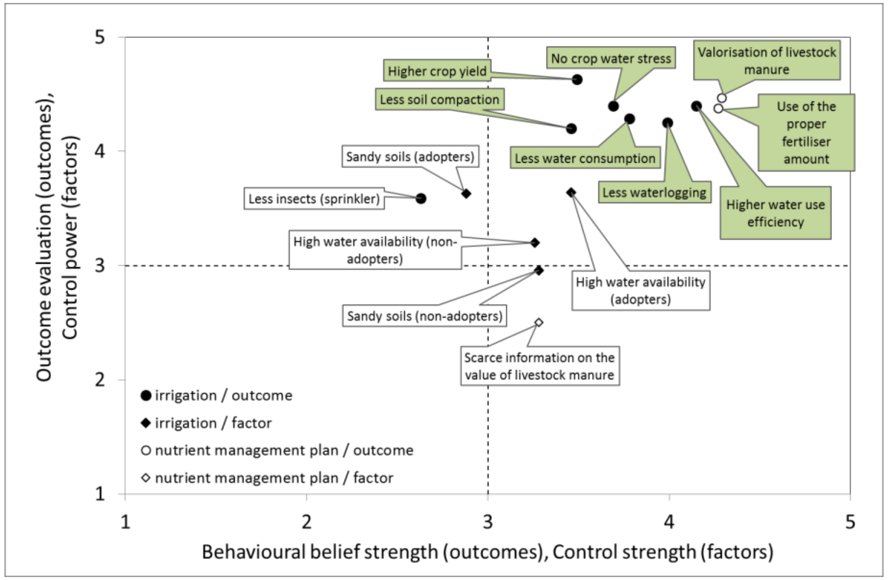
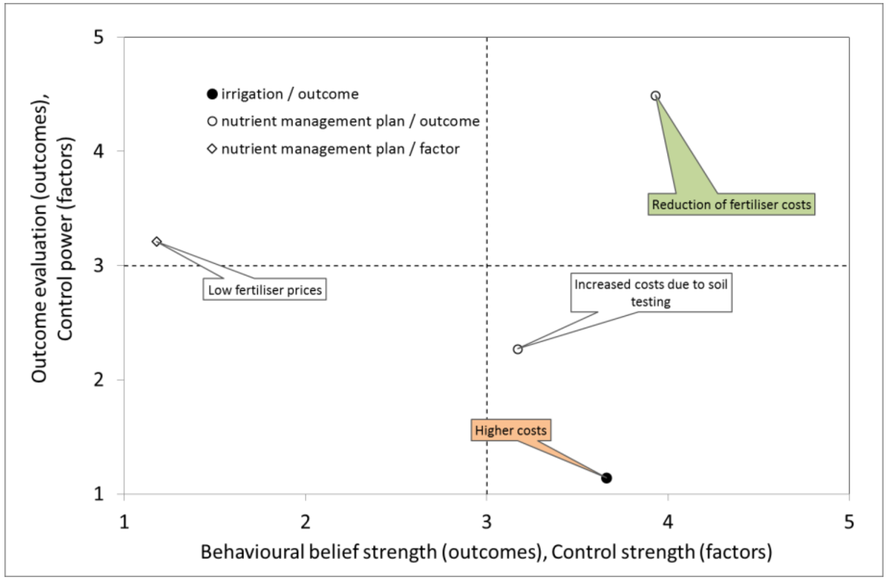

Normative belief (referents)
Motivation to comply (referents)
Advisors of companies selling production factors (adopters)
Advisors of companies selling production factors (adopters)
Feed advisor (adopters)
Advisors of producers associations (adopters)
Other farmers (adopters)
Feed advisor (adopters)
Other farmers (adopters)
Feed advisor (non-adopters)
Advisors of companies selling production factors (non-adopters)
Advisors of producers associations (non-adopters)
Other farmers (non-adopters)
Feed advisor (non-adopters)
Advisors of companies selling production factors (non-adopters)
Other farmers (non-adopters)
▲ rotation with grass meadows / referents
△ rotation with legume meadows / referents

Figure 5. Irrigation and nutrient management plan: average of first and second questions related to (a) soil and environment, (b) financial issues, (c) cultivation technique and (d) social issues. When the combined effect is significantly different between adopters and non-adopters, the symbols are presented separately for adopters and non-adopters in the graph. Drivers are represented in green, and barriers in orange.

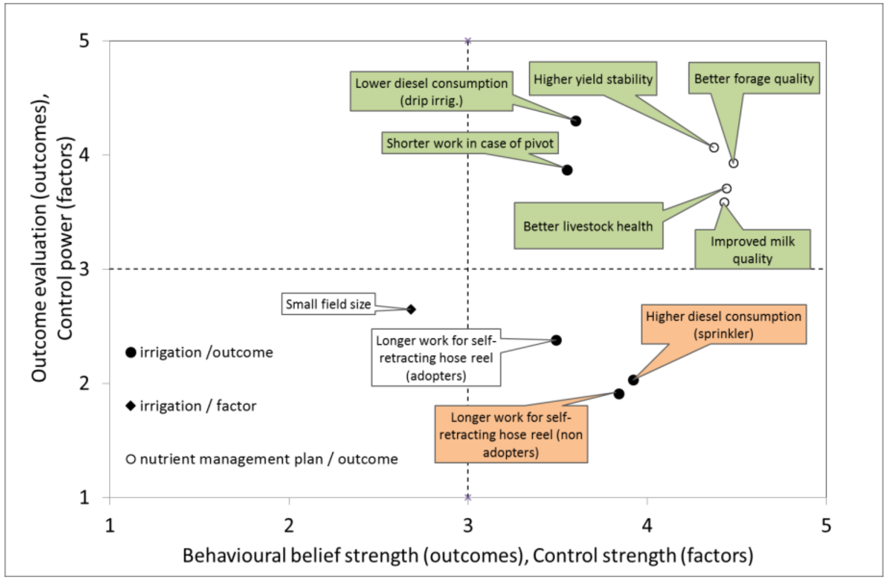
a



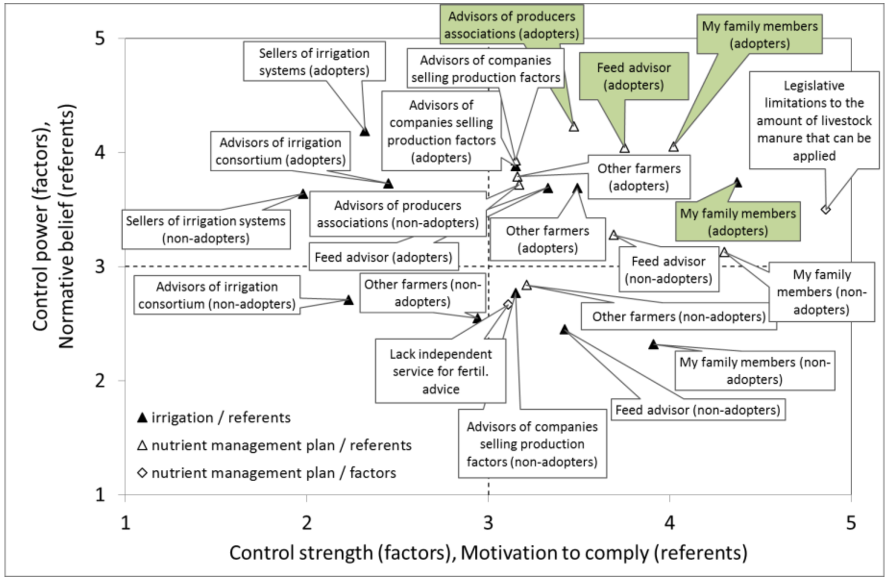
b



c


Lower diesel consumption (drip irrig.)
Higher yield stability
Better forage quality
Shorter work in case of pivot
Better livestock health
Improved milk quality
Small field size
Longer work for self-retracting hose reel (adopters)
Higher diesel consumption (sprinkler)
Longer work for self-retracting hose reel (non adopters)
irrigation /outcome
irrigation / factor
nutrient management plan / outcome
Outcome evaluation (outcomes), Control power (factors)
Behavioural belief strength (outcomes), Control strength (factors)

d


Advisors of producers associations (adopters)
Sellers of irrigation systems (adopters)
Advisors of companies selling production factors
My family members (adopters)
Feed advisor (adopters)
Advisors of companies selling production factors (adopters)
Legislative limitations to the amount of livestock manure that can be applied
Advisors of irrigation consortium (adopters)
Other farmers (adopters)
Advisors of producers associations (non-adopters)
Sellers of irrigation systems (non-adopters)
My family members (adopters)
Other farmers (adopters)
Feed advisor (adopters)
Feed advisor (non-adopters)
My family members (non-adopters)
Advisors of irrigation consortium (non-adopters)
Other farmers (non-adopters)
Other farmers (non-adopters)
Lack independent service for fertil. advice
My family members (non-adopters)
Feed advisor (non-adopters)
Advisors of companies selling production factors (non-adopters)
irrigation / referents
nutrient management plan / referents
nutrient management plan / factors
Control power (factors), Normative belief (referents)
Control strength (factors), Motivation to comply (referents)