SMALL-SCALE DAIRY PRODUCERS' INTENTION TO USE CORN SILAGE AND THE ROLE OF SOCIOECONOMIC AND SOCIO-PSYCHOLOGICAL FACTORS IN DECISION MAKING †

[INTENCIÓN DE PEQUEÑOS PRODUCTORES DE LECHE PARA USAR ENSILADO DE MAÍZ Y EL PAPEL DE FACTORES SOCIOECONÓMICOS Y SOCIO-PSICOLÓGICOS EN LA TOMA DE DECISIONES]

Carlos Galdino Martínez-García[1*], Adolfo Armando Rayas-Amor[2], Anastacio García-Martínez[3], Julieta Gertrudis Estrada-Flores[1] and Carlos Manuel Arriaga-Jordán[1]

[1]Instituto de Ciencias Agropecuarias y Rurales (ICAR), Universidad Autónoma del Estado de México (UAEM), Campus el Cerrillo. El Cerrillo Piedras Blancas, C.P. 50090, Toluca, Estado de México, México. Email. cgmartinezg@uaemex.mx
[2]Universidad Autónoma Metropolitana, Unidad Lerma, División de Ciencias Biológicas y de la Salud, Departamento de Ciencias de la Alimentación. Av. Hidalgo poniente No. 46 Colonia la Estación, 52006. Lerma de Villada, Estado de México, México.
[3]Centro Universitario UAEM Temascaltepec, Universidad Autónoma del Estado de México, México. Km. 67.5 Carretera Toluca-Tejupilco, Barrio de Santiago, Temascaltepec de González. Estado de México. C. P. 51300. México
**Corresponding author*

SUMMARY

Background. Corn silage has shown a better economic sustainability to the small-scale dairy farms; however, the adoption rates among farmers have been low. **Objective**. This paper used the Theory of Planned Behaviour (TPB) to identify socioeconomic and socio-psychological factors influencing farmers' intention to use corn silage. The TPB pointed out that individual's behaviour is conducted by the individual's intention, which in turn is determined by the individual's attitude, subjective norm and perceived behavioural control. **Methodology.** The study was conducted with 106 farmers, divided in users (n=48) and non-users (n=58) of corn silage. To identify differences between groups, the Mann Whitney *U* test was conducted and Spearman's correlations were used to analyse the constructs of the TPB. **Results**. The results showed that users of corn silage had the biggest farm size and their intention was significantly correlated (P<0.05) with the farm characteristics. The TPB's results suggest that users and non-users decisions were based on positive beliefs of corn silage. Users generally perceived a greater social pressure and had a greater motivation to comply, however, non-users manifested to be encouraged by farmer's self-initiative and personnel of the university. Non-users indicated that major constrain to use corn silage was the lack of technical skills and knowledge. **Implications**. The paper adds evidence for a better understanding of factors driving farmer's decisions to use corn silage on the farm. **Conclusions**. The farm characteristics and socio-psychological factors played an important role on farmers decisions to use corn silage on their farms. The findings are of interest for small-scale dairy sector in developing countries.
Key words: Smallholders; corn silage; farmer's decision; adoption and rejection.

RESUMEN

Antecedentes. El ensilado de maíz ha brindado una mejor sostenibilidad económica en los sistemas de producción de leche en pequeña escala; sin embargo, la tasa de adopción ha sido baja por los productores. **Objetivo**. Este artículo utilizó la Teoría del Comportamiento Planeado (TPB, por sus siglas en inglés) para identificar factores socioeconómicos y socio-psicológicos que influyen en la intención de los productores para utilizar ensilado de maíz. La TPB señala que el comportamiento del individuo está dirigido por su intención, la cual es determinada por su actitud, norma subjetiva y control conductual percibido. **Metodología**. El estudio se realizó con 106 productores, divididos en usuarios (n=48) y no usuarios (n=58) de ensilado de maíz. Para identificar las diferencias entre grupos, se realizó la prueba U de Mann Whitney y se utilizaron correlaciones de Spearman para analizar los constructos de la TPB. **Resultados**. Los resultados mostraron que los usuarios de ensilado de maíz cuentan con una unidad de producción más grande y su intención se correlacionó significativamente (P<0.05) con las características de la unidad

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de producción. Los resultados de TPB sugieren que las decisiones de usuarios y no usuarios se basaron en creencias positivas sobre el ensilado de maíz. Los usuarios en general percibieron una mayor presión social y tenían una mayor motivación para cumplir, sin embargo, los no usuarios manifestaron sentirse animados por su iniciativa propia y el personal de la Universidad Autónoma del Estado de México. Los no usuarios indicaron que la principal limitante para usar ensilado fue la falta de habilidades y conocimientos técnicos. **Implicaciones**. El artículo incorpora evidencia que permiten comprender los factores que influyen en las decisiones de los productores para utilizar ensilado de maíz en su unidad de producción. **Conclusiones**. Las características de la unidad de producción y factores socio-psicológicos jugaron un papel importante en el uso de ensilado de maíz en su unidad de producción.
Palabras clave: pequeños productores; ensilado de maíz; decisión del productor; adopción y rechazo.

INTRODUCTION

Small-scale dairy farms are considered an important mean of alleviating rural poverty (Hemme and Otte, 2010) and play an important role in the generation of full-time jobs and daily income for rural families in developing countries; for instance, Honduras, Brazil and Mexico (Reiber *et al*., 2010; Bernardes and Do Rêgo, 2014; Martínez-García *et al*., 2015a). These farms represent almost 20% of the world population (McDermott et al., 2010). In Mexico, data from the agricultural census conducted in 2007 revealed that small-scale dairy farms represented the majority (77%) of the total dairy farms in the whole country; nowadays, these farms have increased up to 88% (INEGI, 2014) and contribute with 37% of the national milk production (Dairy Report, 2012).

Minimise milk production costs is considered as a major concern by small-scale dairy farmers (Martínez-García *et al*., 2015b). The use of moderate amount of commercial concentrates and quality forages such as pastures and corn silage in animal feeding has shown economical sustainability of small-scale dairy farms (Prospero-Bernal et al., 2017). In addition, corn silage has been considered as an innovation that enhance milk production cost and income over feed cost (Bernardes and Do Rêgo, 2014; Celis-Alvarez *et al*., 2016). Corn silage is forage with good palatability and farmers considered that it produced higher milk yield and higher milk fat content (Reiber *et al*., 2010).

In spite of farmers had attended extension programmes on feeding practices about the elaboration of corn silage, they have shown low adoption rates (Reiber *et al*., 2010; Bernardes and Do Rêgo, 2014; Martínez-García et al., 2015a). Reason have been suggested such as farmers consider that corn silage is an innovation that needs substantial financial investments, machinery (chopper), manpower, land, sufficient forage, knowledge and skills (Reiber *et al*., 2010; Bernardes and Do Rêgo, 2014; Martínez-García *et al.*, 2015a).

Studies have been conducted in tropical areas to identify factors influencing farmers' decision to adopt and reject corn silage (Reiber *et al*., 2010; Bernardes and Do Rêgo, 2014). These studies have focused on farmer's criteria, farm characteristics, technical aspects and local conditions (Reiber *et al*., 2010), and also to understand the practices of silage production and utilization on dairy farms (Bernardes and Do Rêgo, 2014). However, there is an existing gap regarding to cognitive and social-psychological factors that influence farmers' decision to adopt agricultural innovation (Martínez-García *et al*., 2013). Therefore, understanding socio-psychological factors that influence farmers' behaviour is an important consideration (Lalani *et al*., 2016).

In the international context, the beliefs, social referents and difficulties that farmers perceive of an innovation have been identified through the Theory of Planned Behaviour (TPB). This approach is useful to understand farmers' decision on adoption or rejection an innovation (Borges *et al*., 2014; Borges and Oude Lansink, 2015; Lalani *et al*., 2016; Van Hulst and Posthumus, 2016) and engagement with extension activities (Hall *et al*., 2019). In the Mexican context the TPB is a novel research tools that have been used to study factors influencing adoption of improved grassland in small-scale dairy farms (Martínez-García *et al*., 2013; Juárez-Morales *et al*., 2017; Martínez-García *et al*., 2018). However, there is no any study about socio-psychological factors influencing small-scale dairy farmers' decisions to use corn silage in Mexico, and in any other country.

The Theory of Planned Behaviour (TPB) explores the rationality that underlies the individual's decision to engage or not engage in a behaviour; however, the use of this theory is valid in circumstances where a person does not have volitional control over the behaviour in question (Zubair and Garforth, 2006). In this study, the use of corn silage is assumed to be under partial volitional control, due to the difficulties perceived by farmers of the innovation; then we hypothesized that farmers' intention to use corn silage could be related to the interplay among a set of socioeconomic variables and socio-psychological factors. Thus, this study makes a contribution to the existing literature through the exploration the role of socioeconomic and socio-psychological factors influencing farmers' decision to use corn silage on the farm and whether comparison of user and non-users of corn silage can improve academic understanding into what is influencing the uptake of innovations. The results are of interest for small-scale dairy sector in developing countries.

MATERIALS AND METHODS

Theoretical framework

This research was based on the social-psychological model of the Theory of Planned Behaviour (TPB) (Ajzen, 2005), it explains that performance of a behaviour is determined by the formation of intention towards the behaviour, which refers to the plan to perform or not perform the behaviour in question (Ajzen and Fishbein, 1980). The TPB hypothesizes that adoption is driven by intention, which is treated as the dependent variable under the influence of three independent determinants, the attitude, subjective norms and perceived behavioural control. These constructs are derived from beliefs (Borges and Oude Lansink, 2015).

In this study, farmer's intention to use corn silage is determined by his i) attitude, it indicates the degree to which execution of the behaviour is positively or negatively evaluated, ii) subjective norm refers to a persons' perception of the social pressure upon them to perform or not the behaviour and iii) perceived behavioural control is the perceived own capability to successfully perform the behaviour (Wauters *et al*., 2010).

In the TPB, direct measures of attitude, subjective norm and perceived behavioural control can be determined by recording the responses of a single question (Martínez-García *et al*., 2018); however, the indirect measures of those three components result of the behavioural beliefs, normative beliefs and control beliefs (Borges and Oude Lansink, 2015). Thus, indirect attitude is derived from behavioural beliefs (b_i*e_i), where b_i is the belief about the likelihood of outcome *i*th outcome of the behaviour, and e_i is the evaluation of the *i*th outcome (Wauters *et al.*, 2010). The indirect subjective norm is derived from normative beliefs (n_j*m_j), where n_j is the belief about the normative expectation of the *j*th important other, and m_j is the motivation to comply with the opinion of the *j*th important other (Wauters *et al.*, 2010). Perceived behavioural control originates from control beliefs (c_k*p_k), where c_k is the belief about the presence of the *k*th factor that may facilitate or inhibit the performance of the behaviour, and p_k is the perceived power of the *k*th factor to facilitate or inhibit the behaviour (Wauters *et al.*, 2010).

In the TPB, socioeconomic characteristics are assumed to influence intention through attitude, subjective norm, perceived behavioural control and beliefs (Borges and Oude Lansink, 2015). However, some authors have explicitly included socioeconomic characteristics to explain farmers' intention to use an innovation (Van Hulst and Posthumus, 2016; Juárez-Morales *et al*., 2017; Martínez-García *et al*., 2018). This study followed these researches to include farmer and household characteristics and farm characteristics as additional variables to explain farmers' intention to use corn silage.

Study area and data collection

The research was conducted in the Municipality of *Aculco*; it is located in the northwest of the State of Mexico, in the middle of the triangle formed by Mexico City, Toluca and Queretaro. *Aculco* has a mean altitude of 2440 m with a sub-humid temperate climate with a dry season from November to April (Celis-Alvarez *et al*., 2016). *Aculco* has traditionally been a milk and cheese production area since 1960s, when government started to invest in infrastructure such as irrigations channels, dams, roads and agricultural innovations which boosted the milk production activity and at the same time the cheese production started to grow (Crespo *et al*., 2014).

The study was carried out in two phases during the period of April-July 2015. In the first phase, open interviews with 20 farmers who were already engaged with the use of corn silage (users) and 20 who were not (non-users) elicited statements of beliefs in relation of the outcomes of using corn silage on their farm in the next year, the people and organisations whose opinions influence farmer's behaviour in respect of using corn silage, and factor that farmers feel restrict their freedom to use it on the farm if they wanted too. The statements that were recorded from the multiple interviews were incorporated into a structured questionnaire to be applied in the second phase. The questionnaire included 12 salient belief statements, seven salient referents and five salient control beliefs (Table 1). The questionnaire also gathered information regarding farmer and household characteristics (farmer's age, farmer's education, farmer's experience, family members and family labour) and farm's characteristics (herd size, milking cows, total milk yield per cow per day, milk sold per day, milk price per litre, total number of hectares and area cultivated with corn).

In the second phase a pilot study was conducted prior to the final survey with 15 farmers in order to identify irrelevant questions and deficiencies in the questionnaire. The interview survey was conducted with 106 farmers (sample includes the 15 previous farmers). To avoid interruptions with the farmers' activities, the interviews were conducted during farmers' free time and milking activity. Participants were identified with a snowball sampling method (Vogt and Burke, 2011) and selected based on two characteristics: a) farmers who were already engaged and not in the use of corn silage, and b) farmers with a herd size of 5 to 35 animals; this criterion has been considered to define the small-scale dairy farmers in

central Mexico (Juárez-Morales *et al*., 2017). In order to develop an understanding of the differences in drivers of adoption of corn silage, the sample was divided in users (n=48) and non-users (n=58).

Data analysis

The five variables which describe farmer and household characteristics (farmer's age, farmer's education, farmer's experience, family members and family labour) and the seven variables that describe farm's characteristics (herd size, milking cows, total milk yield per cow per day, milk sold per day, milk price per litre, total number of hectares and area cultivated with corn) were subjected to non-parametric Mann-Whitney *U* tests with SPSS version 24 to identify differences ($P<0.05$) between users and non-user of corn silage, after examination for normal distribution with Kolmogorov-Smirnov test (Field, 2013).

The components of the TPB ($A=\sum b_i e_i$ and $SN=\sum sb_j m_j$ and $PBC=\sum c_k p_k$) were measured and analysed as follow. Intention to behave (IB) is measured by asking how probable or improbable or weak or strong the individuals feel that they will perform the particular behaviour (Ajzen and Fishbein, 1980). Therefore, farmer's *intention* to behave (IB) was measured by asking, how strong is your intention to use corn silage on your farm in the next year? And the responses were recorded on a five point Likert type scale (Bryman and Cramer, 2011) ranging from very weak (1) to very strong (5). To identify variables correlated with users and non-users intention, Spearman's rank order correlations (Field, 2013) were conducted with the five variables that describe farmer and household characteristics, and the seven variables that describe farm's characteristics.

Direct measures of TPB

The direct attitude, subjective norm and perceived behavioural control were measured according to Martínez-García *et al*. (2018). The *direct attitude* was determined by recording the response of the following question: how important would it be to use corn silage on your farm in the next year? The responses were recorded on a five points Likert type scale, ranging from unimportant (1) to very important (5). The *direct subjective norm* was obtained with the question: how likely is it that people whom you most respect would think you should use corn silage on your farm in the next year? The responses were recorded on a five points scale, ranging from very unlikely (1) to very likely (5). The *direct perceived behavioural control* was obtained with the following question: how difficult would it be to use corn silage on your farm in the next year? The responses were recorded on a five points scale, ranging from very difficult (1) to very easy (5).

Table 1. Beliefs, social referents and difficulties identified in the semi-structured interviews.

Outcome beliefs Using corn silage on my farm….	Social referents	Perceived difficulties
Positive beliefs		
Keeps milk production during dry season	Other experienced farmer	Buys or hires machinery is expensive
Increases milk production	Extension agents	Finds an available person with the equipment during the silage season is difficult
Increases the fat contain in milk	Seller of forage	Makes silage when plots are flooded is a constrain
Decreases the use of commercial concentrates	Local University	Requires manpower when the equipment is useless
Keeps the cows with good body condition	Father	Requires good technical skills and knowledge
Provides cheap forage during dry season		
Provides forage of good nutritive quality	Brother	
Provides good intake by cows, avoiding waste of forage.	Uncle	
Negative beliefs		
Demands a high initial investment		
Demands equipment for elaboration		
Deteriorates when it is not well compressed		
Requires availability of land to sow corn		

Indirect measures of TPB

The indirect attitude, subjective norm and perceived behavioural control were measured and estimated as recommended by Ajzen (2005). Thus, the two components of the attitude (A, *indirect attitude*), outcome belief (b_i) and outcome evaluation (e_i) were each measured using a five point scale, ranging from strongly disagree (1) to strongly agree (5) for outcome beliefs and very bad (1) to very good (5) for outcome evaluation. The overall attitude ($\sum b_i e_i$) was obtained by summing all products of the all-salient beliefs ($b_i * e_i$). The two components of the subjective norm (SN, *indirect subjective norm*), subjective belief (sb_j) and motivation to comply (m_j) were also measured on five-point scale ranging from to strongly discourage (1) to strongly encourage (5) and not at all motivated (1) to very motivated (5), for subjective beliefs and motivation to comply respectively. The overall subjective norm ($\sum sb_j m_j$) was obtained by summing all products of the all-salient referents ($sb_j * m_j$). The two components of the perceived behavioural control (PBC, *indirect perceived behavioural control*) were measured on a five-points scale ranging from strongly disagree that the factors would be a hindrance to use corn silage (1) to strongly agree (5) for control belief (c_k) and very difficult (1) to very easy (5) for power of control beliefs (p_k). The overall perceived behavioural control ($\sum c_k p_k$) was obtained by summing all products of the all-salient control beliefs ($c_k * p_k$).

Reliability of scales measure

To measure the reliability of the five points Likert type scale used in each component of the TPB, Cronbach's α coefficient was used (Van Hulst and Posthumus, 2016). The values of 0.7 and 0.8 are acceptable for Cronbach's α, and lower values indicate an unreliable scale; however, when dealing with psychological constructs, values below even 0.7 can be expected because of the diversity of the constructs being measured (Field, 2013). In this research, the Cronbach's α values were 0.745, 0.769 and 0.772, which confirm the reliability of the scales used to measure the components of TPB.

Analysis of the TPB components

As the variables included in the three components of the TPB were all measured on ordinal scales non-parametric tests were adopted; thus, Spearman Rank Order correlation (Field, 2013) was conducted to analyse the data. For the same reason, Mann Whitney *U* test (Field, 2013) was conducted to identify differences between users and non-users of corn silage, regarding farmers' perception of the TPB's components. Therefore, median and interquartile range (IQR) were used as a measures of central tendency and dispersion, rather than mean and standard deviation (e.g. Zubair and Garforth, 2006; Borges and Oude, 2015; Juárez-Morales *et al*., 2017), since median and IQR are more appropriated for non-parametric test than mean and standard deviation (Field, 2013). The data were analysed with SPSS 24. The analysis of the TPB's components is summarized in Figure 1, and the following hypothesis were derived:

H_1: Users' intention to use corn silage on the farm is positively correlated with the variables that describe farmers and household characteristics and farm characteristics.
H_2: Non-users' intention to use corn silage on the farm is positively correlated with the variables that describe farmers and household characteristics and farm characteristics.
H_3: Users' intention to use corn silage on the farm is positively correlated with the direct measures of attitude, subjective norm and perceived behavioural control.
H_4: Non-users' intention to use corn silage on the farm is positively correlated with the direct measures of attitude, subjective norm and perceived behavioural control.
H_5: Users' intention to use corn silage on the farm is positively correlated with the indirect measures of attitude, subjective norm and perceived behavioural control.
H_6: Non-users' intention to use corn silage on the farm is positively correlated with the indirect measures of attitude, subjective norm and perceived behavioural control.
H_7: There are not differences between user and non-users of corn silage regarding to indirect measure of the attitude.
H_8: There are not differences between user and non-users of corn silage regarding to indirect measure of the subjective norm.
H_9: There are not differences between user and non-users of corn silage regarding to indirect measure of the perceived behavioural control.

RESULTS

Comparison of users and non-users of corn silage

Horizontal silos (bunker (15% of farmers) and stacks (85% of farmers) were the structures most commonly used by users to store corn silage. All users sealed silos with black plastic and with soil and tires on top. All users practiced manual removal of silage from silos to feed the cattle. The Table 2 describes the differences between users and non-users of corn silage. Regarding the variables that describe farmer and household characteristics, there were not statistical differences ($P>0.05$) between user and non-users; however, six out of the seven variables that describe farm characteristics showed statistical differences ($P<0.05$) between user and non-users, thus, users of corn silage showed a

Table 2. General characteristics and differences between user and non-users of corn silage.

Variables	Group 1 (n=48) Users of corn silage		Group 2 (n=58) Non-users of corn silage		P^2
Farmer and household characteristics	**Median**	**IQR[1]**	**Median**	**IQR[1]**	
Farmer's age, years	50.0	17.5	44.5	18.5	0.099
Farmer's education, years	6.0	3.0	6.0	3.7	0.809
Farmer's experience, years	28.0	25.0	20.0	20.0	0.131
Family members, individuals	4.5	2.0	4.0	2.0	0.925
Family labour, individuals	2.0	1.7	2.0	3.0	0.324
Farm characteristics					
Herd size, heads	15.0	10.0	8.0	8.0	<0.000
Milking cows, heads	8.0	8.8	5.0	5.0	<0.000
Total milk yield per cow per day, litres	15.5	5.8	10.0	6.2	<0.000
Milk sold per day, litre	125	125	41.5	63.8	<0.000
Milk price per litre, US Dollars[3]	0.28	0.04	0.26	0.04	<0.001
Total number of hectares, Ha	4.5	6.1	3.3	3.1	0.132
Area cultivated with corn, Ha	2.2	4.0	1.5	2.1	<0.041

[1]IQR = Interquartile Range. [2]*P* Value of the Mann-Whitney *U* test (P<0.05). [3]Price on USD, 15.54 MXN (year 2015)

bigger farm size and higher milk yield per cow and better milk price per litre.

Intention of users and non-users to use corn silage

The users' intention to use corn silage in the next year was generally positive, since 63% of farmers reported very strong and 29% strong intention, however 4% of users showed very weak and 4% weak intention; whereas non-users' intentions was negative, since 26% of farmers reported a very weak and 29% weak intention; however, 24% of farmers indicated strong and 12% very strong intention; on the other hand, 9% were undecided. The Mann-Whitney *U* test showed that the users' intention (median=5.0) was significantly greater (*U*=461.00 *P*<0.05) than non-users (median=2.0).

Variables correlated with the intention of users and non-users of corn silage

The Table 3 shows the correlations between users and non-users intention and the farm and household and farm variables. Interestingly, farmer's intention from both groups was not correlated with variables that describe farmer and household characteristics. However, users' intention was significantly correlated (*P*<0.05) with six out of the seven variables, which describe farm characteristics. Surprisingly, there was no any correlation between non-user's intention and variables that describe farm characteristics. Therefore, the H_1 was partial rejected, i.e. users' intention to use corn silage on the farm is positively correlated with the variables that describe farmers and household characteristics and farm characteristics; however, the H_2 was rejected, i.e., non-users' intention to use corn silage on the farm is positively correlated with the variables that describe farmers and household characteristics and farm characteristics.

Direct measures of TPB

Direct measure of attitude, most of the users (79%) indicated that the use of corn silage in the next year would it be very important and 21% indicated to be just important; however, 40% of non-users indicated that it would be very important, 28% important, 24% little important and 8% indicated unimportant. The Mann-Whitney *U* test showed that the importance of the innovation to users (median=5.0) was significantly greater (*U*=759.00 *P*<0.001) than non-users (median=4.0); however, non-users' intention showed a significant correlation (r=0.348, *P* (2-tailed) <0.01) with the direct attitude.

The *direct measure of subjective norm* indicated that 8% and almost half of users (44%) responded that it is very likely and likely respectively; that people whom they most respect would think they should use corn silage on farm in the next year. Over forty percent (44%) indicated that it is unlikely and 4% indicated very unlikely. On the other hand, 9% and 5% of the non-users responded that it is very likely and likely respectively, and over twenty percent (21%) and 65% responded very unlikely and unlikely respectively. The Mann-Whitney *U* test showed that the direct subjective norm of users (median=4.0) was significantly greater (*U*=679.00 *P*<0.001) than non-users (median=2.0); however, non-users' intention showed a significant correlation (r=0.371, *P* (2-tailed) <0.001) with the direct subjective norm.

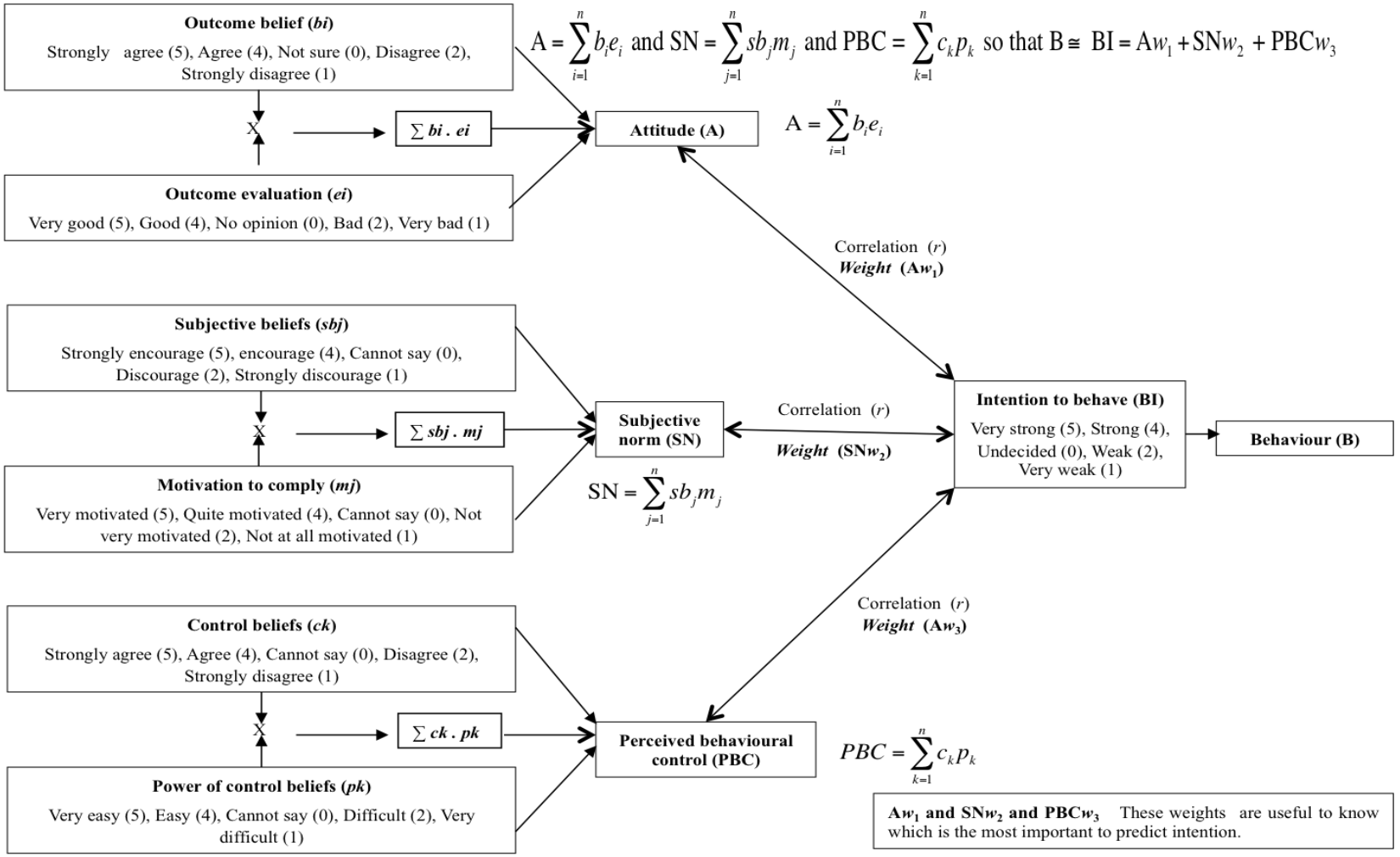

Figure 1. Analysis of the constructs of the Theory of Planned Behaviour (TPB) and it's scales of measure. Source: Constructed using information from: Zubair and Garforth, (2006); Martínez-García *et al.* (2013); Borges *et al.* (2014).

Table 3. Variables correlated with farmer's intention to use corn silage.

Variables	Group 1 (n=48) Users of corn silage Correlation (*r*)	Group 2 (n=58) Non-users of corn silage Correlation (*r*)
Farmer and household characteristics		
Farmer's age, years	0.176 ^{ns}	0.131 ^{ns}
Farmer's education, years	0.120 ^{ns}	-0.025 ^{ns}
Farmer's experience, years	0.120 ^{ns}	0.021 ^{ns}
Family members, individuals	-0.066 ^{ns}	-0-.082 ^{ns}
Family labour, individuals	-0.130 ^{ns}	-0.165 ^{ns}
Farm characteristics		
Herd size, heads	0.330 **	0.141 ^{ns}
Milking cows, heads	0.263 **	0.090 ^{ns}
Total milk yield per cow per day, litres	0.193 *	0.132 ^{ns}
Milk sold per day, litre	0.250 *	0.063 ^{ns}
Milk price per litre	0.225 *	-0.144 ^{ns}
Total number of hectares, Ha	0.782 **	0.161 ^{ns}
Area cultivated with corn, Ha	0.169 ^{ns}	0.063 ^{ns}

ns: showing non-significance
*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Regarding to the *direct measure of perceived behavioural control*, almost twenty percent (19%) and over fifty percent (52%) of the users indicated that the use of corn silage in the next year should it be very easy and easy respectively, and 29% indicated to be difficult; however, 9% of non-users indicated that it should be very easy, 17% easy, 48% difficult and 26% indicated it should be very difficult. The Mann-Whitney *U* test showed that the easiness to use the innovation to users (median=4.0) was significantly greater (U=715.50 P<0.001) than non-users (median=2.0); however, user' and non-users' intention did not show a significant correlation (P<0.05) with the direct perceived behavioural control. Thus, the H_3 was rejected: users' intention to use corn silage on the farm is positively correlated with the direct measures of attitude, subjective norm and perceived behavioural control; however, the H_4 was partial rejected: non-users' intention to use corn silage on the farm is positively correlated with the direct measures of attitude, subjective norm and perceived behavioural control.

Indirect measures of TPB: Correlation between user' and non-users' intention with the indirect measures of TPB

The user' and non-users' intention did not show a significant correlation (P<0.05) with the indirect measure of the attitude; however, non-users' intention showed a significant correlation (P<0.025) with the indirect measure of the subjective norm; whereas user' and non-users' intention did not show a significant correlation (P<0.05) with the indirect measure of perceived behavioural control. Therefore, the H_5 was rejected: users' intention to use corn silage on the farm is positively correlated with the indirect measures of attitude, subjective norm and perceived behavioural control, and the H_6 was partial accepted: non-users' intention to use corn silage on the farm is positively correlated with the indirect measures of attitude, subjective norm and perceived behavioural control.

Indirect measure of attitude and beliefs influencing farmers' decisions

The use of corn silage was viewed as an innovation that may improve production and give economic benefits; however negative beliefs were also identified (Table 4). When looking at median scores in Table 4, significant differences (P<0.05) can be seen between users and non-users, regarding outcome belief (bi), outcome evaluation (ei) and indirect attitude (bi*ei). User and non-users of corn silage differ in seven out of 12 outcome beliefs (bi) regarding the strength of the beliefs that they hold. In the evaluation of outcomes (ei), there were significant differences (P<0.05) in five out of the 12 beliefs. Regarding to the overall attitude towards using corn silage on the farm, users scores were higher (median (IQR) = 272 (38), P<0.05). Thus the H_7 was rejected: There are not differences between users and non-users of corn silage regarding to indirect measure of the attitude.

Users of corn silage showed higher scores in five positive beliefs such as keeps milk yield during dry season, keeps cows with good body condition, provides cheap forage during dry season, provides forage of good nutritive quality and provides good consumption by cows, avoiding waste of forage. In

contrast, non-user evaluated more negatively one belief because of the negative effect of using corn silage such as deteriorates when it is not well compressed.

Indirect measure of subjective norm and social referents influencing farmers' decision

The analysis of the social referents showed significant differences (P<0.05) between users and non-users of corn silage (Table 5) regarding subjective belief (sb_j), motivation to comply (m_j) and indirect subjective norm (sb_j*m_j). Users and non-user differ in seven out of the eight social referents; i.e. the users of corn silage generally perceived greater social pressure from social referents and have a greater motivation to comply with the suggestion of others on using corn silage on the farms.

Apart of the seller of forage, both users and non-users of corn silage differ significantly (P<0.05) in their subjective beliefs about social referents; i.e. comparison of the median scores for subjective beliefs shows that users believe more strongly that social referents should encourage them to use corn silage on the farm; however, non-users manifested to be encouraged by farmer's self-initiative and personnel of the university (Table 5). Regarding motivation to comply, users are significantly different (P<0.05) from non-users regarding their motivation to comply with the opinion of other experienced farmers, self-initiative, personnel of extension services, personnel of university, father, brother and uncle concerning using corn silage on the farm. The overall subjective norm towards using corn silage on the farm, users scores were higher (median (IQR) = 139 (51), P<0.000). Thus, the H_8 was rejected: there are not differences between user and non-users of corn silage regarding to indirect measure of the subjective norm.

Indirect measure of perceived behavioural control and beliefs hindering farmers' decisions

Factors that farmers believe that may hinder or facilitate the use of corn silage are described in Table 6. There were not statistical differences (P>0.05) between users and non-users of corn silage regarding control belief (ck), power of control belief (pk) and perceived behavioural control (ck*pk); however, users and non-users differ significantly (P<0.05) in one out of the five perceived difficulties; i.e, non-users considered that the lack of good technical skills and knowledge make difficult the use of corn silage on the farm. Regarding the summated product of control belief (ck) and power of control belief (pk), representing the measure of the perceived behavioural control towards using corn silage on the farm, users and non-users scores were similar. Therefore, the H_9 was partial rejected: there are not differences between user and non-users of corn silage regarding to indirect measure of the perceived behavioural control.

DISCUSSION

General characteristics of users and non-users of corn silage

The farmer and household characteristics did not showed differences (P>0.05) between users and non-users. This result suggests that farmers share similar characteristics among them; however, users of corn silage showed bigger farm size such as herd size, milking cows, total milk yield per cow per day, milk sold per day, better milk price per litre and land cultivated with corn to produce silage. This finding implies that farm characteristics, mainly the variable land cultivated with corn to produce silage play an important role on farmer's decisions to use corn silage on the farm. Martínez-García *et al.* (2012) pointed out that farm size plays an important role on farmers' decisions to use agricultural innovations.

Farmer's intention and variables correlated

All users of corn silage manifested a strong and positive intention to use the innovation on the farm in the next year; this could be attributed to the length of time (seven years on average) using the innovation, experience gained through the time and the positive benefits observed of the innovation on the farm. Martínez-García *et al*. (2018) pointed out that the longer the time of using an innovation, the stronger the farmer's intention to continue using it. On the other hand, non-users showed the opposite, since over the half of farmer (55%) indicated a negative and weak intention to use the innovation, this could be associated to the lack of experience and technical skills and knowledge to make corn silage; however, the positive and strong intention of non-users (36%) could be associated to the positive beliefs perceived of the innovation.

The variables that describe farmer's characteristics have shown an association with adoption of innovations (Martínez-García *et al*., 2015a); however, the opposite was observed in this study, since there were no correlation between farmer's intention and the variables farmer's age, farmer's education and farmer's experience in both groups, as observed by Lalani *et al*. (2016) in the adoption of conservation agricultural practices. This implies that farmer's intention to use corn silage was not influenced by farmer´s characteristics; therefore, those variables should not be a constraint to adopt the innovation for

Table 4. Comparison of the outcome beliefs (bi), outcome evaluation (ei) and attitude (bi*ei) between users and non-users of corn silage.

	Outcome beliefs (bi)			Outcome evaluation (ei)			Attitude (bi*ei)		
Salient beliefs of using corn silage Using corn silage on my farm...	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2
Positive beliefs									
Increases milk yield	5 (1)	5 (1)	<0.040	5 (1)	5 (1)	0.233	25 (8)	20 (9)	0.069
Increases milk fat content	5 (1)	5 (2)	0.239	5 (1)	5 (2)	0.145	25 (9)	23 (13)	0.209
Keeps milk yield during dry season	5 (0)	5 (1)	<0.029	5 (1)	5 (1)	0.052	25 (5)	20 (9)	<0.024
Decreases the use of commercial concentrates	5 (1)	5 (2)	0.132	5 (1)	5 (2)	0.126	25 (9)	20 (13)	0.108
Keeps cows with good body condition	5 (0)	5 (1)	<0.006	5 (0)	5 (1)	<0.001	25 (0)	25 (11)	<0.001
Provides cheap forage during dry season	5 (0)	5 (1)	<0.013	5 (0)	5 (1)	<0.005	25 (4)	23 (13)	<0.004
Provides forage of good nutritive quality	5 (0)	5 (1)	<0.001	5 (0)	5 (1)	<0.002	25 (0)	25 (10)	<0.000
Provides good consumption by cows, avoiding waste of forage.	5 (0)	5 (1)	<0.013	5 (0)	5 (1)	<0.001	25 (0)	25 (10)	<0.001
Negative beliefs									
Demands a high initial investment	5 (0)	5 (.3)	0.301	5 (1)	5 (1)	0.866	25 (5)	25 (9)	0.435
Demands machinery for elaboration	5 (0)	5 (1)	0.444	5 (1)	5 (1)	0.721	25 (5)	25 (6)	0.783
Deteriorates when is not well compressed	5 (0)	5 (1)	<0.042	2 (1)	1 (2)	<0.001	11 (4)	8 (3)	<0.001
Requires availability of land to sow corn	5 (0)	5 (.3)	0.723	5 (1)	5 (1)	0.923	25 (9)	25 (5)	0.799
∑bi	58 (6)	55 (9)	<0.021						
∑ei				58 (6)	56 (13)	0.083			
∑bi*ei							272 (38)	258 (84)	<0.013
Cronbach´s α coefficient of scale reliability									0.745

[1]IQR = Interquartile Range.
[2]*P* Value of the Mann-Whitney *U* test (P<0.05).

Table 5. Comparison of the subjective belief (sbj), motivation to comply (mj) and subjective norm (sbj*mi) between users and non-users of corn silage.

	Subjective belief (sb_i)			Motivation to comply (m_i)			Subjective norm (sb_i*m_i)		
Salient referents	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2
Other experienced farmer	4 (2)	2 (1)	<0.000	4 (1)	4 (1)	<0.007	16 (13)	12 (9)	<0.004
Self-initiative	5 (1)	4 (2)	<0.000	5 (1)	4 (2)	<0.000	25 (9)	12 (19)	<0.000
Personnel of extension service	4 (2)	2 (2)	<0.000	4 (2)	4 (1)	<0.000	16 (15)	9 (12)	<0.000
Seller of forage	2 (2)	2 (2)	0.093	2 (2)	2 (1)	0.281	9 (15)	4 (11)	0.137
Personnel of university	4 (1)	4 (1)	<0.000	5 (1)	4 (2)	<0.001	20 (9)	16 (11)	<0.001
Father	5 (1)	2 (2)	<0.000	5 (1)	4 (1)	<0.001	22 (14)	12 (10)	<0.002
Brother	5 (1)	2 (2)	<0.000	5 (1)	4 (1)	<0.000	25 (9)	12 (11)	<0.000
Uncle	5 (1)	2 (2)	<0.000	5 (1)	4 (1)	<0.000	20 (9)	12 (10)	<0.000
∑sbj	4 (2)	2 (1)	<0.000						
∑mj				32 (5)	28 (9)	<0.000			
∑sbj*mj							139 (51)	99 (66)	<0.000
Cronbach´s α coefficient of scale reliability									0.769

[1]IQR = Interquartile Range.
[2]*P* Value of the Mann-Whitney *U* test (P<0.05).

Table 6. Comparison of the control beliefs (ck), power of control beliefs (pk) and perceived behavioural control (ck*pk) between users and non-users of corn silage.

	Control belief (c_k)			Power of control belief (p_k)			Perceived behavioural control (c_k*p_k)		
Perceived difficulties	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2	Users Median (IQR)[1]	Non-users Median (IQR)[1]	P^2
Buys or hires machinery is expensive	5 (1)	5 (1)	0.335	2 (2)	2 (1)	0.508	20 (15)	16 (19)	0.232
Finds an available person with the machinery during the silage season is difficult	5 (1)	5 (1)	0.737	4 (2)	4 (3)	0.489	16 (15)	16 (17)	0.264
Makes silage when plots are flooded is a constrain	5 (1)	5 (1)	0.850	2 (2)	2 (1)	0.230	18 (15)	16 (17)	0.352
Requires manpower when the equipment is useless	5 (0)	5 (1)	0.429	4 (2)	4 (3)	0.182	18 (15)	16 (15)	0.128
Requires good technical skills and knowledge	5 (1)	5 (1)	0.300	2 (2)	1 (2)	<0.004	20 (12)	13 (17)	<0.017
∑ck	24 (4)	24 (4)	0.500						
∑pk				20 (17)	18 (15)	0.236			
∑ck*pk							84 (47)	80 (69)	0.156
Cronbach´s α coefficient of scale reliability									0.772

[1]IQR = Interquartile Range.
[2]*P* Value of the Mann-Whitney *U* test (P<0.05).

small-scale dairy producer, as observed in the group of users of the innovation.

The significant correlations ($P<0.05$) of users' intention with the variables herd size, milking cows, total milk yield per cow per day, milk sold per day, milk price per litre and total number of hectares, indicated that the users' intention is associated with the farm characteristics, i.e. the better the farm' characteristics, the stronger the users' intention to use corn silage on the farm in the next year; similar results were observed by Martínez-García *et al*. (2013) in the adoption of improved grassland. However, non-users' decisions were based beyond farmer and farm characteristics, since none of the variables were correlated with intention.

Direct measures of attitude, subjective norm and perceived behavioural control

The importance of corn silage to users could be attributed to the fact that is an innovation already in use and farmers realise the advantages on the farm. On the other hand, the significant correlation ($P<0.01$) between the non-users' intention and the direct attitude implies that the more the non-users consider the innovation to be important on the farm, the stronger the farmers' intention to use it. The results of the direct subjective norm suggest that users' decisions can be influenced by people that whom they most respect; whereas, the opposite was observed in the non-user, since they indicated that it is unlikely; however, the significant correlation ($P<0.05$) of the non-users' intention with direct subjective norm, implies that the more the non-users who think that people that they most respect could influence their decisions, the stronger the non-user' intention to use corn silage. Therefore, extension services should be designed and conducted to encourage and increase the adoption rate of corn silage among non-uses who consider the innovations to be important and their decisions can be influenced by social referents. For example, an extension approach that takes into a count the peer-to-peer learning, learning from farmers' own experience and observation could be a suggestion, as recommended by Hall *et al*. (2019).

The direct perceived behavioural control indicated that most of the users (71%) manifested that the use of corn silage should it be easy in the next year; this could be attributed to the fact that farmers are already engaged with the use of the innovation; therefore, they have the knowledge and skills to use it on the farm; however, the opposite was observed on non-users, since most of the farmers (74%) manifested that the use of corn silage should it be difficult, this could be attributed to the lack of experience, skills and knowledge to use the innovation. Martínez-García *et al*. (2015a) indicated that the major constraints to adopt new innovations are the lack of experience and knowledge about how to use them. On the other hand, the farmers' intention in both groups was not influenced by the perception of the difficulty or easiness to use the innovation; this implies that other factors could be influencing farmers' decision such as farm's dimension as it was observed with the user of the innovation.

Indirect measures of attitude, subjective norm and perceived behavioural control

Indirect measure of attitude and beliefs influencing farmer's decision

The significant differences ($P<0.05$) in scores of the users and non-users of corn silage for beliefs supporting attitudes suggest that the decision to use or not corn silage on the farm is influenced by farmer's perception of the advantages and disadvantages of the innovation, as was found by Martínez-García *et al*. (2018) in the adoption of improved grassland. The favourable attitudes (drivers) towards using corn silage stem from the beliefs that using corn silage on the farm keeps milk yield during dry season, keeps cows with good body condition, provides cheap forage during dry season, provides forage of good nutritive quality and provides good consumption by cows, avoiding waste of forage. Similar beliefs were reported by Reiber *et al*. (2010) in a study on promotion and adoption of silage in small-scale dairy farmer from Honduras. Policies and programmes for promoting the use of corn silage should seek to encourage the positive beliefs, especially among farmers who have not already been engaging on the use of corn silage. If the drivers are strengthened and spread among farmers, there is a bigger probability that people adopt the innovation. Hall *et al*. (2019) pointed out that farmers appreciated learning from other farmers, and favoured extension taking place on farm, supplemented with an expert speaker or experienced facilitator.

Indirect measure of subjective norm and social referents influencing farmers' decision

Findings of the indirect subjective norm indicated that social pressure played an important role on users' decision to use corn silage on the farm; therefore, peer pressure was a key factor influencing farmers' decision. Borges *et al*. (2014) pointed out that the closer social referents such as relatives, friends and other experienced farmers played an important role in the communication of improved grassland. Moreover, the social networks of relatives, friends and group of farmers are important avenues in the communication of innovations (Adegbola and Gardebroek, 2007). On the other hand, non-user manifested to be encouraged by the personnel of the university; this finding implies that extension approached should be conducted with expert speakers or experienced facilitators, addressing

the perception that extension activities should be designed for less experienced farmers, as pointed out by Hall *et al*. (2019).

Beliefs that prevent farmers' decision to use corn silage

No statistical differences ($P>0.05$) between user and non-users of corn silage regarding control belief (ck) imply that farmers from both groups were agree that perceived difficulties that hinder the use of the innovation on the farm; moreover the results of the power control belief indicated that perceived difficulties such as buys or hires machinery is expensive, makes corn silage when plots are flooded is a constrain and requires good technical skills and knowledge were perceived by users and non-users as the main difficulties. Similar constrains were founded by Bernardes and do Rêgo (2014) in a study of practices of silage production and utilization for Brazilian dairy farmers.

Non-users more negatively evaluated the three main perceived difficulties, i.e. the more the non-users consider the perceived difficulties as constrains, the less the non-users' intention to use corn silage on the farm. Therefore, to overcome the perceived difficulties; which include buys or hires machinery, makes corn silage when plots are flooded and requires good technical skills and knowledge, the following suggestions should be considered: i) create lines of credit and stimulate the formation of cooperatives to increase the purchasing power of farmer to buy machinery as recommended by Bernardes and do Rêgo (2014), ii) extension programmes must be conducted in the farm of the dairy producers to develop knowledge and technical skills (Martínez-García *et al*., 2015a). Thus, farmers' intention to use a new innovation may increase, when the process of transfer innovations is companied with a good technical assistant (Borges *et al.*, 2014).

CONCLUSIONS

Findings showed that farmers who use corn silage reported a strong intention to use it in the next year; moreover, it was associated with most of the variables which describe the farm characteristics; therefore, part of users' decision were based on farm characteristics, since played an important role on users' intention to use corn silage. Even though, most of the non-users reposted a weak intention and none of the variables studied were correlated with it, in order to increase adoption rate of corn silage, the few farmers who showed a positive intension could be targeted as a starting point for extension services to promote and to encourage the use of corn silage.

The results of the direct attitude, indicated that the importance of the innovation in both groups played an important role on farmers' decision to engage; moreover, the indirect attitude, revealed positive and negative beliefs that favour and constrain farmers engagement in the use of corn silage. Therefore, user' and non-users' decision were based on their beliefs. Thus, attitude was found to be the stronger predictor of farmers' intention.

The direct and indirect subjective norms showed that the users of corn silage generally perceived greater social pressure from social referents and had a greater motivation than non-users to comply with the suggestion on using corn silage; however, non-users manifested to be encouraged by farmer's self-initiative and personnel of the university; Therefore, the social referents played an important role on farmers' decision to use corn silage. Thus, the social referents identified in the research could be considered as source of knowledge and communication of corn silage among small-scale dairy farmers.

The direct measure of perceived behavioural control indicated that most of the non-users responded that the use of corn silage should be difficult in the next year; however, the major constrains identified in the indirect measure of the perceived behavioural control for both groups were mainly associated with lack of money to buy machinery, climate conditions i.e. inundated plots and lack of skills and knowledge. Therefore, subsides should be considered as a mean to encourage farmers to buy machinery and it must be accompanied with technical assistant to develop knowledge and skills to make corn silage.

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Data availability. Data are available with the corresponding author at: (cgmartinezg@uaemex.mx) upon reasonable request.

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