Article

Design and implementation factors associated with the performance of an extension program in Mexico

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Abstract

For extension programs to achieve their objective, they must be pertinent and effective, that is, their design and implementation should be considered. Therefore, this research analyzed the effect of factors regarding the design and implementation of an extension program on its performance, which was measured, based on the changes achieved, with the innovation adoption index. For this, the characteristics of the production units served, technicians hired, and the variables associated with the implementation of the program were compared with the innovation adoption index of 921 corn producers in the state of Veracruz, Mexico, who received technical support in 2017 and 2018, through comparisons of means and correlations. The results showed positive changes in the innovation adoption index with an average increase of 6.3% in eight of nine municipalities ($p<0.05$). The attributes of the production units that favored the adoption were the prior use of hybrids, mechanized tillage and commercialization, while in the operation, the timely start of the service in relation to the phenological stage of the crop, the experience, rooting and the exclusive dedication of the technicians were the positive factors. Likewise, the density of the knowledge network increased slightly with the innovation adoption index. This may indicate that, by promoting the interaction among producers, the adoption of innovations could improve. Thus, it is suggested that the design and implementation of future extension programs should consider the heterogeneity of the target population, promote the indicated characteristics of the technicians, start the operation in a timely manner and explicitly promote the interaction between producers.

Keywords: adoption of innovations, agricultural extension work, implementation, innovation networks.

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Introduction

Agricultural extension has had different conceptions since it emerged as a discipline and profession. Traditionally, agricultural extension was defined as the process by which an innovation was developed by scientists, transferred by extension personnel and adopted by farmers (Rivera and Sulaiman, 2010). In Latin America, this linear transfer approach, introduced in the fifties, evolved from the late sixties and during the seventies towards a new conception focused on facilitating communication processes in which producers and rural communities would play an active and leading role (Berdegué, 2002). Specifically in Mexico, the concept has evolved from an external assistance vision towards a logic of self-management (Rendón *et al*., 2015), although in practice the extension processes require reforms to overcome their linear and transference character (Solleiro *et al*., 2017).

The present research adopts the definition of extension proposed by Leeuwis (2004), who conceived it as a series of integrated communicative interventions that aim, among other things, to develop and induce innovations that supposedly help solve problematic situations (usually of multiple actors). The proper definition of problematic situations allows focusing the analysis on which should be, and which should not be problems where extension processes are convenient.

In Mexico, extension programs have proposed since 1980 to address a variety of objectives, such as achieving food security, reducing technological gaps, capitalizing producers and adding value, strengthening technical and administrative capacities, among others; so that recurrent changes in the definition of objectives have not allowed the achievement of any (Rendón *et al*., 2015). The lack of a clear definition of the objectives of the extension system in general is noticeable and therefore the beneficiary population is also not defined (IICA, 2011).

To achieve its proposed purpose, any intervention through extension work activities must have a series of attributes: pertinence and effectiveness (Santoyo, 2013). That is, it must be an extension system suitable for the purpose to be achieved and based on this, specify what the intervention will do and how it will do it, seeking an agile budgetary operation and the strict application of technical criteria in the operation.

There is currently a consensus on the need to analyze extension policies to verify their success or failure, in order to generate evidence that allows better informing policy decisions through a series of learnings based on analytical debate and argumentation of the entire process (Santoyo, 2013; Rendón *et al*., 2015; Santoyo *et al*., 2016).

In the field of public policies, Sabatier and Mazmanian (1979) affirm that the success of a public policy depends to a large extent on three factors: i) the treatability of the problem considering, among other aspects, the diversity of the attention groups; ii) the performance of the statutes to structure the implementation through an appropriate causal theory; iii) non-statutory variables attributed mainly to the context offered by variations over time, or between local environments of social, economic and technological conditions and to the support of the institutions involved, including financial and supervisory management, among others.

Therefore, to analyze an extension program, it is necessary to consider the results it obtained, considering its purpose, the attributes of the target-attended population, the operational criteria implemented and the management of the knowledge network, among other aspects.

Thus, the objective of the present study was to analyze the effect of factors associated with the design and implementation of an extension program on its performance, measured based on the changes achieved in the innovation adoption index (InAI). A previous consideration is that the concept of agricultural innovation adopted in this research is that of Rogers (1983), which is distinguished by being extended to any idea, practice or object that is perceived as novel by an individual or other unit of adoption. In this sense, agricultural practices are considered innovations depending on the novelty with which they are perceived.

Materials and methods

Sources of information

The sources of information used for this study were: Database of 921 corn producers with areas equal to or less than 5 hectares, beneficiaries of the technical support implemented within the framework of the PROAGRO Productivo program of SAGARPA, generated from the collaboration agreement 'mapping of innovation networks PROAGRO Productivo 2017 and 2018', signed between the Chapingo Autonomous University (UACH, for its acronym in Spanish) and the International Maize and Wheat Improvement Center (CIMMYT, for its acronym in Spanish). It includes as variables the area, yield, use of machinery, use of hybrids, percentage of marketed production, innovations adopted and sources of information referred by producer for each innovation.

Records of the PROAGRO program and semi-structured interviews applied in person to 17 extension workers who attended to the indicated producers. The variables included were the start of activities in relation to the phenological stage of the crop, which may be on time (sowing or vegetative development) or late (maturation or harvest), the experience of the technician with the crop and as an extension worker, their exclusive dedication towards the program and the technician's prior knowledge of the communities (rooting to the territory).

Spatially, the scope of the research was limited to studying the implementation of technical support in the state of Veracruz and 9 municipalities were considered: Comapa, Cotaxtla, Papantla, Perote, San Andrés Tuxtla, Santiago Tuxtla, Soteapan, Tantoyuca and Zongolica. The temporality of the study considers the operation of the program in 2017 and 2018, which were the only years in which the intervention was present.

Performance indicators

To assess the performance of the intervention the InAI was calculated (InAI= number of innovations adopted by the producer/number of innovations in the catalog $*100$) for each producer, was used the method of Muñoz *et al*. (2007) from 13 innovations: soil analysis, application of foliar, permanent beds, compost, balanced fertilization, soil improvers, micronutrients, mycorrhizae, MasAgro seeds, precision sowing, ripping, seed treatment, and use of plastic bags or silos.

One consideration is that all practices have the same specific weight on the indicator and that the adoption of each of them contributes 7.7 percentage points in the indicator of each producer. The InAI was calculated for 2017 and 2018 to assess its increase and its statistical significance.

A second indicator that was estimated was the innovation adoption rate (IAR) for each innovation for the same years, to visualize the changes in adoption for each innovation. The calculation was made using the method proposed by Muñoz *et al*. (2007), using the following formula: IAR= number of producers who used the innovation/total number of producers∗100.

The third indicator that was used to assess the results of the intervention was the density of knowledge networks (KNs) from 2017 to 2018, which were computed in the UCINET 6.2 software, under the approach of social network analysis, from the sources of information to which farmers attributed the learning of each innovation they implemented. The KNs were paired considering the total number of actors that made up the KNs in both years. The KN density indicator shows the percentage of existing relationships in relation to those that could exist considering the actors that make up the network (Molina *et al*., 2010).

Information analysis

The significance of the change shown by the InAI at the municipal level was assessed through t-tests for related samples. The analysis of the IAR was carried out by comparing proportions with the Chi-square test, with special attention to the existing asymmetries on which innovations increased in number of adopters and which did not, to define possible causes from documentary review, the context and the characteristics of the population studied.

To determine whether the changes in KN densities were statistically significant, the networks were paired by considering the total actors of the network of each municipality for both years but maintaining the existing links in each year and were evaluated using the routine: Network> Compare densities> Paired (same nodes) in the UCINET 6.2 software, under the bootstrap paired sample t-test method proposed by Snijders and Borgatti (1999). Changes in the density of paired KNs at the municipal level were correlated with corresponding changes in the InAI in order to identify whether there was a relationship between the two variables.

Subsequently, the analysis focused on the increase in InAI in relation to a set of variables that could condition the adoption of innovations. These variables can be grouped into two broad categories: i) characteristics of production units; and ii) operational criteria that were implemented, mentioned in the section on information sources. The variables were contrasted with the increase in InAI (Δ InAI), through correlations and mean comparison analysis.

Results and discussion

Performance indicators

The first result that was estimated was the increase in InAI at the state level and for each municipality that was analyzed. Table 1 also shows the number of farmers by municipality.

Table 1. Increase in the level of innovation by municipality.

Municipality	N	InAI 2017	InAI 2018	Dif.	SE of the dif.	Sig.
State	921	10.8	17.1	6.3	0.2	0
Comapa	60	13.3	17.1	3.8	0.7	0
Cotaxtla	83	8.4	21.1	12.7	0.5	0
Papantla	129	11	18	7	0.5	0
Perote	90	9.8	16.9	7.1	0.3	0
San Andrés Tuxtla	113	7.2	11.9	4.7	0.5	0
Santiago Tuxtla	55	17.4	22.7	5.3	0.6	0
Soteapan	154	13.5	26.4	12.9	0.4	0
Tantoyuca	153	10.7	10.8	0.1	0.2	0.413
Zongolica	84	8.1	9.6	1.5	0.3	0

The program resulted in an average increase in InAI of 6.3% in the nine municipalities of Veracruz. In absolute terms, this equates to 0.8 innovations adopted per producer. Although the little interest in the introduction of innovations can be caused by factors such as risk aversion and lack of liquidity (Martínez and Gómez, 2012), in this case, the low levels of adoption, being such small-scale producers, could be the result of agriculture not being their main activity, which makes the opportunity cost of their effort very high in relation to the potential reward obtained from other sources of income (De Janvry and Sadoulet, 2004; CONEVAL, 2015).

In addition, of the nine municipalities that received technical support, one had an increase of 12.9%, equivalent to 1.7 innovations on average, and another of 0.1%, equivalent to 0.04 innovations. Therefore, the results are asymmetrical among the population attended. Some studies agree on the heterogeneous performance between regions of the same technical assistance scheme, generally attributing it to differences in local conditions (Muñoz *et al*., 2014; Martínez-González *et al*., 2018). However, as will be seen later, the characteristics of the operation also influence the performance of the adoption of innovations. Regarding the adoption of each innovation, which was estimated by the IAR, Figure 1 shows the variability of this indicator for the two years analyzed.

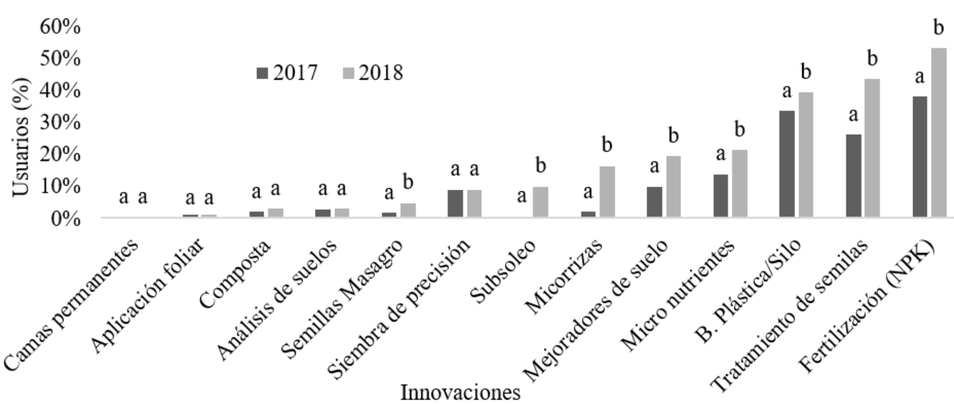

Figure 1. Changes in the innovation adoption rate. Different letters indicate significant differences ($p < 0.05$); chi-square test.

The most adopted innovations were balanced fertilization, seed treatment and grain preservation by plastic bag or silo. Innovations that, although they increased their adoption, were already relatively known by producers before. Except for MasAgro seeds, ripping and mycorrhizae, significant changes did not occur in innovations with values lower than 10% of adopters in the initial IAR.

On the other hand, given that all the producers who were attended received incentives for the purchase of fertilizers and seeds (SAGARPA, 2017), this mechanism contributed to the adoption of innovations associated with these inputs. The adoption of plastic bags is explained by the relatively low cost of the technology and by the late start of the program's activities in the field, in relation to the phenological stages of the crop in 2017, as this situation caused extension activities to focus on the dissemination of post-harvest management practices.

Additionally, the KNs also showed changes in density as shown in Table 2, which also includes additional information such as the number of actors referred and the number of network links for each year.

Table 2. Density of KN generated by municipality.

Municipality	N	No. of actors referred		No. of links		Density (%) (paired samples)		Dif.
		2017	2018	2017	2018	2017	2018	
Comapa	60	17	113	88	156	0.68	1.21	0.53*
Cotaxtla	83	20	41	90	238	0.057	1.51	0.94*
Papantla	129	54	57	152	280	0.44	0.81	0.37
Perote	90	66	76	109	217	0.4	0.79	0.39
San Andrés Tuxtla	113	24	28	104	179	0.53	0.91	0.38*
Santiago Tuxtla	55	19	21	103	145	1.81	2.54	0.74
Soteapan	154	12	165	16	316	0.57	1.1	0.53
Tantoyuca	153	9	13	142	144	0.52	0.53	0.01
Zongolica	84	11	11	75	86	0.84	0.96	0.12

*= the difference is statistically significant ($p < 0.05$).

In general terms, the modules started operations in networks with low densities, which means limited information exchange flows. Although all KNs increased density, only three municipalities did so significantly: Comapa, Cotaxtla and San Andrés Tuxtla. The municipality with the greatest increase in density was Santiago Tuxtla; however, it started from the initial network with greater density.

Although the Extension Program took advantage of existing social interaction, it could not improve the interaction of less dense initial networks such as that of Perote, Papantla and Tantoyuca. This program established a set of activities oriented towards the management of interaction between producers, although in practice, the criteria for the selection of demonstration modules and extension areas were based on traditional issues such as those pointed out by Rendón *et al*. (2016): regulatory compliance, interest and empathy of the producer with the program and the proximity and access to the plot, since the program required to quickly identify where the modules would be established and with which producers the working group would be constituted.

Implementation factors associated with performance

According to the general behavior of the adoption of innovations, nuances were found in the variability of the results of the program. One aspect that was associated with the adoption of innovations was the technological context, which includes the use of hybrids and the use of machinery. The variability of these factors is shown in Table 3.

Table 3. Influence of the technological context on the adoption of innovations.

Variable	Use of hybrids			Use of machinery		
	No	Yes	Sig.	No	Yes	Sig.
InAI 2017	10.6	11.3	0.177	11	10.2	0.078
InAI 2018	15.2	21.6	0	16.9	17.6	0.253
Δ InAI	4.7	10.3	0	5.9	7.7	0

According to the increase in InAI, it is claimed that PUs that used hybrid seeds and mechanized tillage obtained better results than PUs where the use of these technologies was limited. The foregoing provides evidence that the most technified producers and with more commercial agriculture were favored to a greater extent by the program. While farmers with low and medium rates of commercialization behaved similarly, the adoption of innovations was higher in those farmers with a high rate of commercialization, as shown in Figure 2.

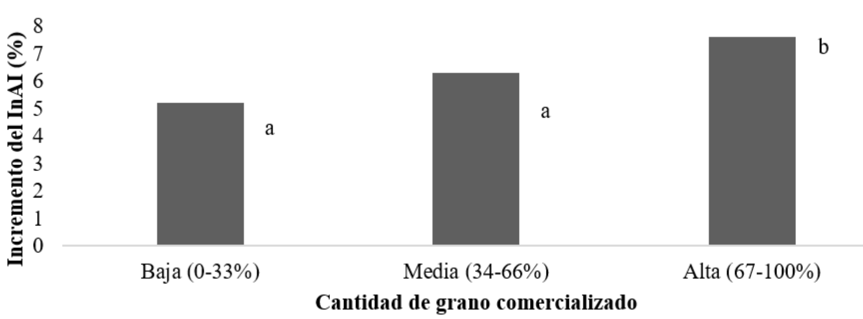

Figure 2. Marketed grain and adoption of innovations (Scheffé test). Different letters indicate significant differences ($p < 0.05$).

For its part, the area did not show a significant correlation in relation to the increase in InAI (Pearson's r= 0.055; $p > 0.05$). One possible explanation is that, as they are small areas, the variability of the adoption of innovations decreases. Yield showed a positive, albeit low, correlation with the increase in InAI (Pearson's r= 0.23; $p < 0.05$). One likely explanation is that producers with better yields tend to have positive experiences with technology adoption and therefore a greater willingness to innovate.

Other studies have found a relationship between superior yields and the incorporation of innovations in crops such as potatoes (Priegnitz *et al*., 2019), or between the expectation of yield and the adoption of conservation agriculture practices (Knowler and Bradshaw, 2007). In Veracruz, the intensity of this relationship is low, possibly due to the heterogeneity of the regions, the dominant orientation of the cultivation towards self-consumption and the low participation of the activity in income.

In addition, the variability in InAI changes has to do with the operating environment under which the intervention was executed. A first aspect was the timeliness of technical support in the first year; when the start of the activities of the program coincided with the sowing or vegetative development stages of the crop (on time), the increase in the adoption of innovations was greater than when the start of activities occurred in the stages of maturation or harvesting of the crop (late), as indicated in Table 4.

Table 4. Start of operations in relation to the phenological stage of the crop and increase in the adoption of innovations.

	On time	Late
Δ InAI (%)	7 b	0.2 a

This situation has also been perceived as a common problem by other extension workers in Mexico (Monsalvo Zamora *et al*., 2017). In effect, starting late implies operating with restrictions for the promotion of the entire catalogue of innovations, reduction of the attractiveness of the program for farmers, inopportune diagnoses and with little use value, inertial selection of producers and modules; and, in general, less practical work on plots.

On the other hand, characteristics of the extension workers that were favorable with the adoption of innovations were identified: prior knowledge of the territory where they provided their services and technical support as the only source of income (Table 5).

Table 5. Influence of the technical advisor’s profile on the adoption of innovations.

	Knew the territory		Sig.	Exclusive dedication		Sig.
	Yes	No		Yes	No	
Δ InAI (%)	5.8	0.1	0	7	3.7	0

The exclusive dedication in the extension and the rooting to the territory has been limited to a large extent in Mexico by two processes: delays in payments and uncertainty in the continuity of the program. PROAGRO’s technical advisors indicated late payments in periods of between two and four weeks, which represents an improvement with respect to what Muñoz and Santoyo (2010) indicated for the fiscal year 2009, where in 75% of the states, payments to PSP were made late, in ranges that vary from two weeks to four months. However, according to the regulations of the Program, payments were subject to the delivery of products, if the products were not delivered by the technician, the payment was not made until compliance was finalized, so attributing the delay to an administrative problem is a statement that must be taken with caution.

Fifty-nine percent of PROAGRO's technical advisors resorted to other sources of income during the program, all of them indicated that late payments were the main cause. This coincides with Mayoral *et al*. (2015), who point out that, in a study carried out in Baja California, of 40 extension workers surveyed, only 18% dedicated themselves exclusively to the activity.

On the other hand, it can be said that extension workers do not perceive that this profession is sustainable, since federal investment for agricultural extension programs has presented wide variations in the period 2011-2018, with reductions from 2014 to 2016 (Rendón *et al*., 2019). Influencing the territorial roots and exclusive dedication of extension workers requires in practical terms a review of the incentives to open spaces and increase the attractiveness of the profession (Berdegué, 2002).

Additionally, a positive correlation was found between the increase in InAI with the experience of extension workers both in the crop (Pearson's r= 0.34; $p< 0.05$) and in professional activity (Pearson's r= 0.37; $p< 0.05$). This means that eligibility criteria are a precondition for strengthening the quality of the offer of the service providers (Muñoz and Santoyo, 2010) and given the relative ease of application, these criteria should be strictly considered. In addition, the current development of the extension and its orientation to effectiveness requires the selection of advisors with a competency-based approach (Tarekegne *et al*., 2017).

On the other hand, a clear positive relationship (r= 0.74) was found between the increase in InAI and the increase in the density of paired KNs. The technical support of PROAGRO Productivo had a strong orientation towards the management of interaction and complied with a series of guidelines for the development of innovation networks (Muñoz and Santoyo, 2010): mapping of the knowledge network, identification of key actors and identification of tacit knowledge, in addition to the preparation of reports for technical advisors based on the dissemination potential of farmers. Although the operation times limited the strict application of these criteria in the selection of modules, the results of the network intervention (Valente, 2012) did manage to be associated with the increase in InAI (Figure 3).

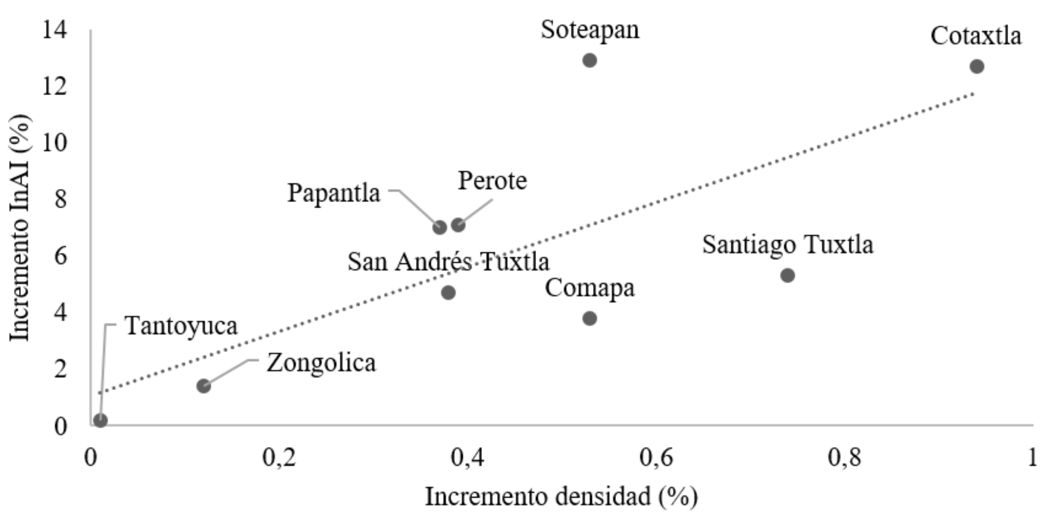

Figure 3. Management of social capital and its influence on the adoption of innovations.

The smallest increases in InAI occurred in Tantoyuca and Zongolica, where the density increases of KNs were also the smallest. The largest increases in InAI occurred in Soteapan and Cotaxtla, the latter being the municipality where there was the greatest increase in the density of KNs. Given that producers innovate as their social interaction grows (Monge and Hartwich, 2008), it is suggested that future interventions also explicitly promote the management of producer interaction for learning purposes.

The promotion of innovation through interaction management requires overcoming the traditional criteria for the selection of producers and modules, based on regulatory aspects and individual attributes of the target population, by moving to criteria such as dissemination potential (Rendón *et al*., 2016). A process of this type requires, of course, longer times for the implementation of the diagnostic and planning stages. If improvements in KN are achieved, innovation levels could also be improved in the future, as it tends to remain beyond the validity of the program.

Conclusions

In this study, it was found that there is a relationship between the factors of the design and the implementation of the extension program with the adoption of innovations. The technical assistance strategy attended a target population with contrasting conditions and differences in the results achieved were found in favor of farmers who were more technified and better connected to markets. Therefore, if a population attended is very heterogeneous, the expected results will not be achieved with a single strategy in the entire universe attended, so it is necessary to design specific strategies for each type of producers. Another factor that was related to the adoption of innovations was the start of activities in relation to the phenological stage of the crop.

It was found that, if the start of activities is late, the adoption of innovations is restricted to a narrow spectrum of innovations. Therefore, timeliness is essential to influence the key processes of agricultural innovation. Subjecting action schedules to administrative constraints causes limited results. This aspect is key to the design of the program.

The roots and exclusive dedication of the extension workers were related to the performance of the program. However, these factors were not considered as selection criteria for extension workers. Including them, in addition to experience, will contribute to improving the quality of services in future extension programs. Additionally, the application of a system of hiring, payment and continuity that rewards and encourages the performance of extension workers is a crucial element for the achievement of results.

The producers innovated as their social interaction grew because in PROAGRO Productivo, the explicit promotion of activities allowed the management of the interaction of producers for learning purposes. This allows knowledge to remain and moved among farmers, as this knowledge network tends to remain beyond the validity of the program.

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