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INNOVATION'S ADOPTION BY FARMERS: EVIDENCE FROM MILA REGION OF ALGERIA

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ABSTRACT

The dairy cattle sector has experienced a significant change since the country's independence due to the implementation of modern breeds imported from Europe. This innovation is introduced to remedy the problems of the low milk production of local breeds and meet the needs of the populations to fill the protein deficit. The State has put in place instruments to facilitate the introduction of new techniques through subsidies. The question of adopting and disseminating innovations also arises in terms of coordination between different actors who should take charge of the process of adopting innovations. The innovations that are developed and/or adopted by breeders with a direct or indirect impact on the product obtained can be on dairy cows, on the quality of feeding, or on farming conditions. In our study, we hypothesized that contact with other economic, technical and institutional agents facilitates the dissemination of innovations and their adoption, whereas, most of the contacts established by breeders are personal due to the absence of technical institutes in the region. The main obstacles to innovate are of several types: natural, managerial, financial, and institutional.

KEY WORDS

Innovation, subsidies, networks, adoption, adaptation.

To ensure that the local agri-food system be capable to respond to the new needs with the widest possible benefits, it is necessary that the operators of the sector introduce new forms of technological, organizational and social innovation and collaboration in their production, transformation and distribution activities.

First, in Algeria the milk continues to represent the primary source of animal protein in the food ration. In 2013, it contributed 54% of the ration of animal proteins, far exceeding meats (red and white) (32%), fish (5%) and eggs (9%) (Faostat, 2020).

The national supply of raw milk is provided by four (04) types of females: cow, sheep, goat, and camel; but the cow milk represents more than 90% of the national supply. The milk sector in Algeria is of particular interest through the various agricultural and food policies (program to rehabilitate the milk sector (1995), National Agricultural Development Program(2001), National Agricultural and Rural Development Program(2002), and the Agricultural Renewal Program (2009) because of the importance of "milk" as a staple of Algerian consumers.

Thus, the consumption (availability) of milk and dairy products per inhabitant per year experienced significant growth between 1968 and 2016. Since, the Algerian consumed 35 kg per inhabitant per year in 1963 (Bedrani & Bouaita, 1998) and consumes currently 157 kg per inhabitant per year (according to availability calculated from national supply and imports). This significant consumption is the result of the consumption subsidy policy launched by the Algerian State in order to fill the deficit in proteins of animal origin, noted after the independence of the country, where the milk is therefore the cheapest animal protein.

However, over the past two decades, the national availability of milk and milk products hasn't been constant, characterized rather by decreases and increases from one year to another (with an annual growth rate of 1%).

This situation explains the difficulties in covering the needs for milk and milk products during this same period. These national milk supplies are largely provided by imports of milk powder and the anhydrous milk fat (In 2009, imports covered 68% of dairy supplies).

Developments in imports of milk powder show periods of decline, which can be explained by the higher cost of milk powder on the international market. This product reached historic highs in 2007-2008. Since 2007, a vertiginous increase in the prices of all industrial dairy products has been observed. It was immediately followed by a dramatic drop in 2008 and 2009, then a sharp rebound in 2010 and a slight decline in 2014, which stood at \$ 3,600 per ton for the whole milk powder (Makhlouf, 2015).

In parallel, imports of milk ingredients also depend on oil prices on the international market. The fall in oil prices observed from 2014 makes it difficult for Algeria, under this financial constraint, to import the required quantities in the same way. Especially since the country is committed to the new dairy policy from 2008 to the reduction of imports of powder and the development of local production to guarantee its food security.

In response to the low competitiveness of farmers, the ministry of agriculture launched the document on the development objectives of the strategic agricultural sectors where there are five key ideas which constitute the matrix of the new growth model, namely: (i) private investment as a new engine of growth agricultural; (ii) integration for better construction of value chains; (iii) innovation as a key to modernization and development of agriculture and fisheries; (iv) irrigation for a sustained increase in productivity; and (v) inclusiveness as a guarantee of efficient participation of actors and balanced development of territories. This new direction is dictated by the new situation marked by the fall in international oil prices (since 2014).

Little empirical research has addressed the issue of adoption of innovations in Agriculture in Algeria ((Derderi et al., 2015; Ould Rebai et al., 2017; Naouri et al., 2020; Bouzid et al., 2020).

The dairy cattle breeding sector, which constitutes the strong link for the dynamics of the dairy sector, has known in the past (after the independence of the country) an important change, characterized by the introduction of modern breeds imported mainly from Europe, commonly called MDC (Modern dairy cattle). This change can be described as innovation (in the sense of Schumpeter) by the fact of the introduction of new breeds to Algerian dairy farms. This innovation is introduced to remedy the problems of the low milk production of cows of local breeds and meet the needs of the populations to fill the protein deficit noted after the country's independence.(in 1962).

This model was conceived on the basis of the conviction that only "modern" breeding technology can make it possible to achieve the objectives set out in sufficiently short time. In addition, through the ripple effect of this same innovation ((Bourbouze et al, 1989); other innovations have been adopted : a new breed of dairy cow was born following the crossing of the modern breed and the local breed (Atlas Brunus) commonly called IDC (Improved Dairy Cattle) (Laribi, 2005), the introduction of the milking machine which can facilitate milking for cows with high dairy potential, the introduction of artificial insemination to preserve the genetic characteristics of modern imported breeds (MDC) , a high quality and rich diet (imports of corn and soybeans), intense veterinary care, better conditions for the stables (animal's habitat).

Ferrah, (2000); Bencharif, (2001) stated that cows of modern breeds (imported) found difficulties to adapt to the Algerian conditions characterized by frequent supply shortages (livestock feed, veterinary products, etc.), and insufficient health monitoring, in addition, the fails to adapt to the pedo-climatic conditions.

The State has set up subsidy programs to facilitate the adoption of these innovations likely to promote the local production. We cite the example of artificial insemination, which was subsidized at 80% since 1995 (Milk Rehabilitation Program), the milking machine was subsidized at 50% then at 30% to be eliminated, automatic drinkers, silage technique, fitting out and modernization of dairy barns.

It should be noted that the support for these innovations has changed through agricultural policies. These programs are temporarily frozen for financial reasons. In addition, as part of a new dairy policy launched since 2008, other innovations have been introduced by the State with the aim of improving farming conditions to encourage the adoption of innovations. These innovations are characterized by political measures as loan policy, three

new banking products from 2011: R'fig loan, Ettahdi-loan, unifying credit, policy to support artificial insemination and an organizational innovation which favoured the contractual arrangements between the dairies, collectors and the breeders. This organizational innovation (contracts) should encourage the adoption of innovations through supplier credit for the acquisition of modern dairy cows; feed (silage), and the acquisition of the milking machine.

In this new context characterized by new political and economic data, the questions that arise are: "What characteristics of the innovator-farmers and what types of innovations are adopted and from where?"

The question of the adoption and dissemination of innovations also arises in terms of coordination between different actors who should take charge of the process of adopting innovations. These actors can be producers, extension agents, farmers (breeders, grain farmers, tree growers, etc.), institutions (banks, administrations, etc.).

The main hypothesis to be verified in this research, which is widely verified in other contexts (Diederer et al., 2003; Hermans et al., 2015 ; Lappe et al, 2019; Bouzid et al, 2020), is that the performance of farms depends on the level of innovation. The general observation made by specialists is that Algerian agriculture remains highly dependent on climatic hazards and vulnerable to water stress, the cause being linked to its poor modernization. The first indicator which supports this hypothesis is that of the very strong fluctuation in the growth rate of the volume of agricultural production, depending on the climatic years.

According to literature, the determinants of adoption are the structural variables of the farm (the useful agricultural area), the mode of access to land, the personal characteristics of the farmer such as age, level of education, and professional experience.

In order to improve productivity per dairy cow, increase national production and consequently reduce imports, the public authorities have put in place several measures to promote the adoption of new breeding techniques. The remainder of the article is organized as follows: an overview of the Algerian dairy sector, followed by a presentation of the study region and a section dedicated to present the results and discussion.

The evolution of local milk production experienced an average annual growth rate of 5% for the period 2000-2016 (Figure 1). This evolution can be explained by several factors:

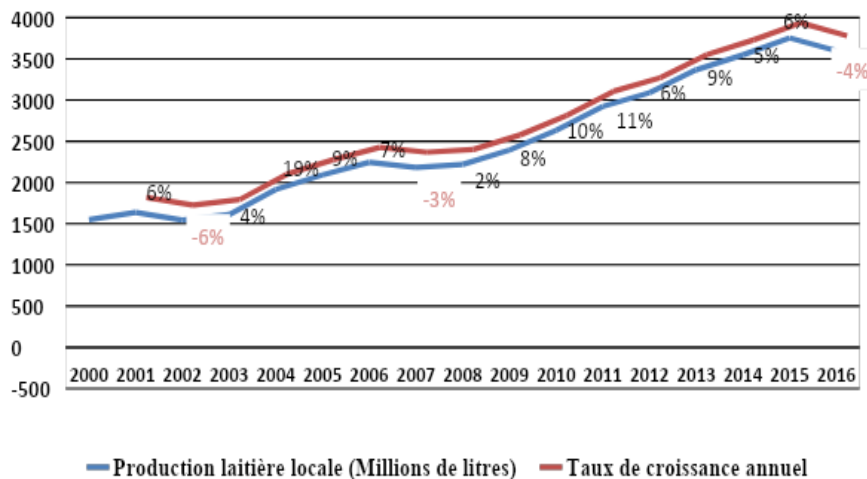


Figure 1 – Evolution of local milk production (Million litres). Source: MADR, 2018.

In the Algerian context, the government was, and continues to be, the principal actor in agriculture and tried to introduce technical innovations in the sector.

In the dairy sector, many improvements have been done via the public policies:

- Improvement of the organization of the dairy sector by the National Inter-professional Milk Office (ONIL), re-activated in 2008 following the constraint of external shocks linked to the high volatility of world prices for milk powder (2007-2008). This office is responsible for the organization, supply and stability of the national market for

pasteurized milk packaged in sachets, made from the only imported powdered milk (ONIL, 2020).

- In terms of price policy, there was a revision of the producer prices of raw milk produced at the level of dairy farms (This price went from 27 Da / litre (in 2008) to 36-38 Da / litre (2016) and a revision of the subsidy premium (from 7 Da / litre (before 2008) to 12 -14 Da / litre (+ two (02) dinars/litre for the sanitary health in 2018) (ONIL, 2018).
- In addition, imports of heifers contribute considerably to the development of milk production. The country's financial difficulties following the application of the structural adjustment plan, added to the import bans (from 2000 to 2003) due to the epidemics which struck the European livestock (main source of supply) led to a considerable fall in livestock (13%). Till 2004 the imports resumed (31,000 head in 2004, 20,000 in 2005 and 50,000 in 2006). From 2007 to 2012, cumulative imports of pregnant heifers reached around 70,000 heads of different highly dairy breeds. According to the ministry data, the annual average of imports during 2012 -2015 is 27.400 heads per year. In total, about 487.921 cows were imported from 1964 to 2015 (Kheffache & Bedrani, 2012; MADR, 2018). In spite of these continuous imports, livestock growth does not follow the same logic, with an annual growth rate of 2.98%. For the same period (2000-2016) an annual average growth rate of 2.92% for the evolution of the livestock. In contrast, the forage areas showed an annual average growth rate of 3.6%. These areas are characterized by a dominance of the dry fodder crops. They represent 24% of herbaceous crops.

MATERIALS AND METHODS OF RESEARCH

Our methodology is based on the definition made by Schumpeter who introduced innovation in economics, considers that innovation is the act of exceptional entrepreneurs who bring about a change capable of provoking a real dynamic in the company and of raking in profits due to the added value provided by the innovation in question. However, it is the idea that innovation as the first phase of development, the second being the upheaval and the third the re-composition of the economic system (Deblock & Fontan, 2012). The international organizations have made different definition to this concept and we have retained these related to agriculture:

The Organization for Economic Cooperation and Development (**OECD**) and Eurostat (2005) define innovation as "the implementation of a new product (good or service) or of a product that has undergone substantial improvements, or a new process, a new marketing technique or a new method of work organization and external relations".

World Bank (2010): innovation "corresponds to technologies or practices which are new to a given society. These are not necessarily news in absolute terms, but they are diffused in this economy or this society. This aspect is important: what is neither disseminated nor used cannot be considered as innovation". The World Bank also discusses the social benefits of innovation: "Innovation, which often consists of providing new solutions to existing problems, must ultimately benefit many, including the poorest".

Food and Agriculture Organization (2019) has developed a working definition of agriculture that emphasizes the impact of innovation on food security, sustainability and development outcomes: "Agricultural innovation is the process by which individuals or organizations give a social and economic dimension to new or existing products, processes or modes of organization in order to improve efficiency, competitiveness, resilience to shocks or the viability of an ecological point of view and thus contribute to food and nutritional security, economic development and the sustainable and nutritional management of natural resources".

For Hartwich & Negro, (2010), innovation is concerned with the search for and discovery, experimentation, development, imitation, and adoption of new products, processes, organizational set-ups, ideas, and skills. The results of Läßle & Thorne, (2019) reveal that innovative farmers can achieve higher economic gains by further innovation.

Overall, our findings support the current focus of the Irish extension system on fostering the uptake of innovative technologies and practices in order to achieve an economically sustainable expansion of the dairy sector.

In the field of animal production, innovation is omnipresent. According to Meynard and Dormad (2014), intense innovation activity has marked the history of animal husbandry: domestication and selection of breeds have made it possible to secure and improve human food. Over the years, animal breeding and feeding practices have constantly evolved, adapting to the diversity of ecosystems and the needs of human populations, integrating technological and agronomic progress. The origin of these innovations has changed over time, moving from "breeder-specific" innovations- defined by (Lefort, 1988) "as a new practice or way of doing things" - to external innovations characterized by massive intervention by research institutions and industries "whether upstream or downstream of the activity". Ultimately, according to Bal et al (2003), cited by Ingrand et al., (2014) the majority of innovations in agriculture have mixed sources, i.e. both endogenous and exogenous. Some practices are initiated by farmers in the field, and then studied in depth by public and private research institutions in order to understand and explain the mechanisms of action of these practices with a view to optimizing them (Fortun-Lamothe & Davost, 2017).

The measurement of innovation within farms is based on the standard reference, survey questionnaire inspired by the Oslo manual (OECD, 2005) with some adaptations to the local context and to the agricultural sectors studied. Two surveys were conducted: a quantitative survey to measure innovation in a representative sample of farms, and a qualitative survey (semi-directives) with a sample of players in innovation systems in the strategic agricultural sectors studied.

The choice of the study region of Mila is part of the natural dairy basin in the northeast of the country, containing a number of 1.388 dairy cattle breeders identified by the Veterinary Inspection of the Wilaya in 2018.

By its second place in terms of production, the commune of Oued Athmania records developments in the processing of raw milk which was intended (for the most part) for dairies outside the region.

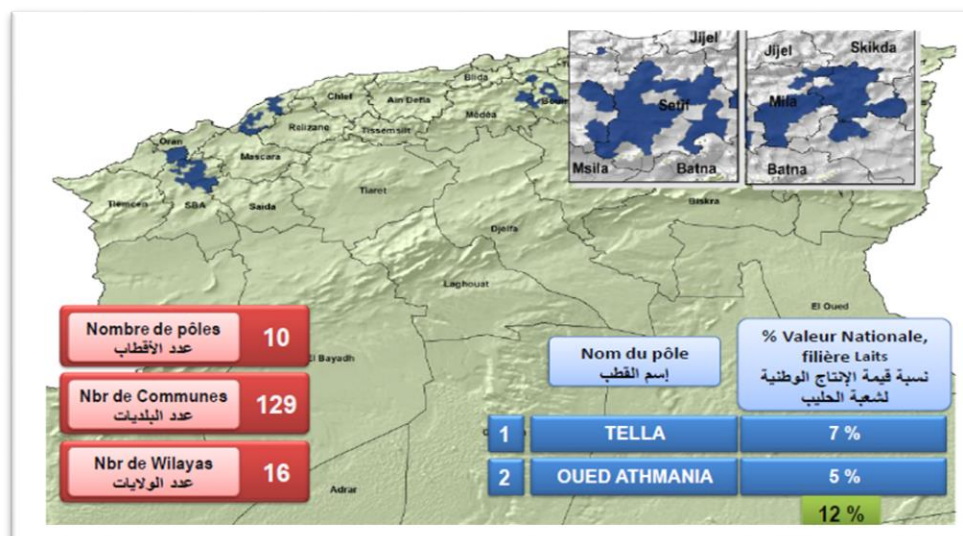


Figure 2 – Dairy poles in Algeria (Source: Ministry of Agriculture)

The region has a significant potential for dairy cows, i.e. 44.761 cows, of which 27.351 heads of IDC (Improved dairy cattle) and LDC (Local Dairy Cattle) and 17.410 heads of MDC (Modern Dairy Cattle), leads in extensive and intensive breeding and an estimated milk production of 93.877 K litres of milk for collection of 17,562,000 litres in 2011 (DSA Mila, 2018). Collection is carried out by 76 approved collectors (including collection centres set up by dairies outside the region). It has been chosen as a dairy agropolis by the Ministry of

Agriculture (Figure 2). This classification of agricultural poles was made on the basis of the number of breeders in each region and the production obtained.

The choice of *Oued Athmania* region was dictated by its classification by the ministry as a dairy basin with 427 identified breeders with 3.016 dairy cows, or 7DC / breeder on average. This town is among the ten (10) centres of excellence in dairy production in Algeria after that of Tella in Sétif.

In terms of fodder resources, dry fodder crops are more dominant in crop rotation. The dominant agricultural production system is the practice of cattle, goat and sheep farming with a number of 230.540 sheep heads, 82.268 goat heads and 101.794 cattle heads. Thus dairy cattle farming are associated with the dominant practice of grazing and dry feeding.

Our sample consists of 67 breeders. These breeders were chosen randomly (in order to avoid statistical bias) and distributed geographically on the territory of the municipality. This choice is justified by the absence of an updated database on active breeders in the region; but also by the absence of the breeders during the interviewers' visits to the breeding workshops. Our objective was to have a sample which includes small breeders (0-5 dairy cows), medium breeders (5-10 dairy cows) and breeders with more than 10 dairy cows.

The survey sample is mainly represented by the age category between 36-59 years, who are relatively old, young people represent only 19.4%. They are 90% of the farmers surveyed, who have a low level of education (average level (35%), primary (31%), illiterate (23%). There are only 6 breeders who have followed agricultural training (technician in agriculture, short-term training). The majority of breeders (77%) declares having had links or made contact with the agricultural administrations (in particular the agricultural subdivision, the Directorate of agricultural services, the veterinary inspection of the wilaya, the laboratory of analysis of the soil and the universities.) But the breeders declare that they have never contacted the technical institutes for the search for technical information. This is explained by the fact that there are no technical institutes (Artificial Insemination Centre, Technical Breeding Institute, etc.). At the study region (Wilaya de Mila, in particular the commune of *Oued Athmania*), which are concentrated at the level of the wilaya of Algiers (Technical Breeding Institute, Agricultural Extension Institute), in Sétif El-Eulma (CNIAG East Regional Centre).

Relative to the practice of non-agricultural activity, they are 4 breeders who exercise liberal activities. 10 farmers only breed different species (cattle, sheep and goats) without practicing other crops (cereals, market gardening). Unlike the majority, (57 breeders) practice mixed farming-breeding (cereal farming, market gardening -bovine-goat-sheep-broiler).

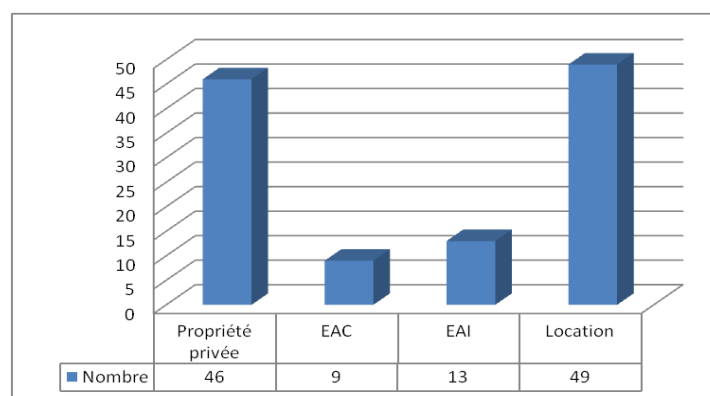


Figure 3 – The legal status of the farm (Source: Established from the survey data)

Dairy cattle breeding are practiced mainly on private dairy farms; there are 46 breeders out of 67 who own private land (Figure 3). Collective or individual agricultural farms (private State estates by concession) represent only a small percentage of the dairy farms surveyed (collective with 9 breeders and individual with 13 breeders). Renting agricultural land is a dominant practice in within the breeders of *Oued Athmania*, represented by 49 breeders; it comes to remedy the problems of access of the breeders to the land to have additional

sources of production capacities in particular cereal and/or fodder through informal arrangements based on the visual estimation of yields (spontaneous fodder or other crops) and trust between the partners. The rental also concerns access to land left fallow.

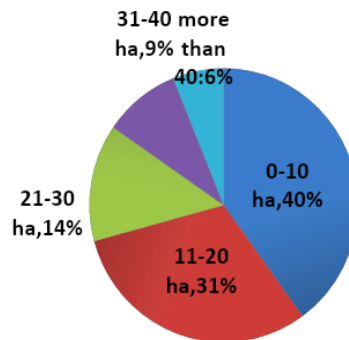


Figure 4 – The useful agricultural area and irrigated area of farms (Source: established from the survey analysis)

The useful agricultural areas are relatively medium in size (0-20ha). They are 71% of the owners, who own less than 20 ha, 40% of who have less than 10 ha (Figure 4). The majority of farmers (43 farmers, or 64% of the sample) do not irrigate the totality of their agricultural areas. The rest of the breeders (24 breeders) irrigate very small areas. 83% of them irrigate less than 5 ha (mainly represented by profitable crops (market gardening). The main reason is the difficult access of farmers to water resources (river, dam, drilling) because of the difficulties of having authorizations to access water from the dam and authorization to dig the well or borehole.

In the dairy farms surveyed, the diversity of the practices of other farms (cattle, sheep, goats, and poultry) is dominant. The breeders surveyed have 608 dairy cows, including 181 MDC and 427 (IDC and LDC). The average size per cow per farm of the sample is 9 ± 5 cows. This size is slightly higher than the average for the municipality (7 cows' ± 4 per farm) and the national average, which are 6 cows or 8 per farm.

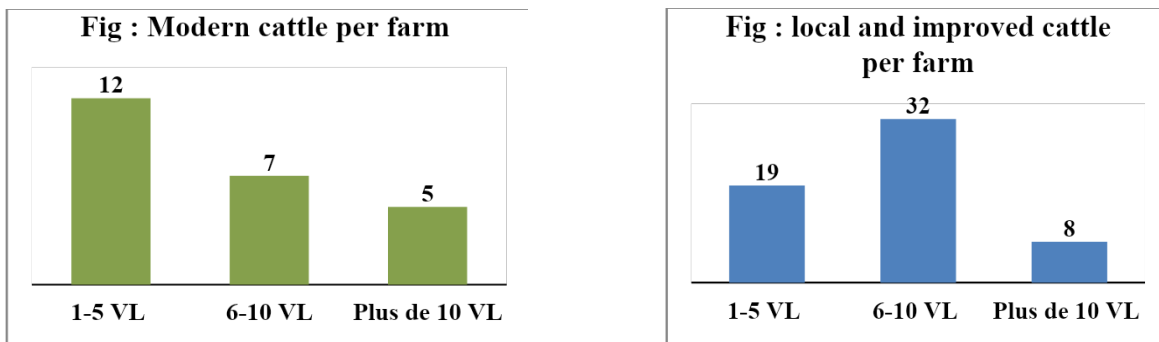


Figure 5 – Distribution of breeders according to the cows owned (modern, local, improved). Source: Established from the survey analysis.

Modern cows are imported and recognized for their high genetic potential. There are only 24 breeders surveyed who own modern breeds (Figure 5), representing in terms of milk production 36% of the sample; local dairy cattle presented by the rustic local breed coming from the brown breed of d 'atlases; and the improved dairy cattle, resulting from the crossing of modern breeds and local breeds Atlas browns, are dominant in dairy farms. Indeed, there are 59 breeders who hold local and improved breeds, represented by 88% of the sample.

In the Mila region, farming and livestock farming in particular is a family activity. In the study sample, most of the breeders (93%) use family labour for reasons of cost (free labour compared to seasonal and salaried labour), and availability (Table 1).

Table 1 – The distribution of breeders according to the workforce

Workforce	Sex	Number of breeders
Family workforce	Female	2
	Male	56
Seasonal workforce	Female	
	Male	1
Salaried workforce	Female	1
	Male	5

Source: Established from the survey analysis.

This family workforce covers all farm activities in addition to sowing, harvesting, transport, milking, barn maintenance, etc. However, the use of hired labour to cover the lack of family labour is only represented by 6 breeders.

RESULTS AND DISCUSSION

Two underlying themes emerged from analysis of our primary data: product & process and organizational & marketing innovations.

Innovation occurs through the collective interplay among many actors – including farmers, researchers, extension officers, traders, service providers, processors, development organizations – and is influenced by factors such as technology, infrastructure, markets, policies, rules and regulations, and cultural practices (actors' values and norms). Thus, innovations are not just about technology but also include social and institutional change, and have a systemic and co-evolutionary nature (Biggs, 1990; Leeuwis & van den Ban, 2004).

(Adell & Pujol-Andreu, 2016) showed that cattle improvement played a significant role in Central and Northern Europe from the mid nineteenth century (by increasing the yields). Also, they stated that in Spain, the development of the dairy was based on the increasing number of cows.

In our context, the innovations that are developed and/or adopted by breeders with a direct or indirect impact on the product obtained (raw milk) can be on dairy cows (genetic improvement by artificial insemination), on the quality of feeding (green fodder, improved livestock feed, farming methods, choice of varieties and new irrigation techniques), and on farming conditions (animal welfare, barn, and veterinary care).

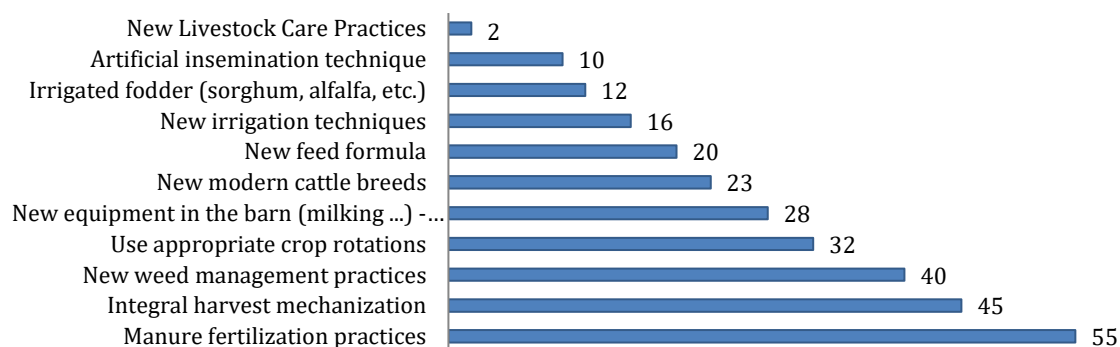


Figure 6 – Product and process innovations (Number of breeders).

Source: Established from the survey analysis.

In order of importance (Figure 6), the most adopted innovations in this type are those related to the production of cow feed: the use of manure for fertilization (82% adoption rate), the mechanization of crops (wheat and fodder) with 67.2% of farmers who have adopted this innovation which aims to reduce crop losses and minimize the use of labour; the use of weed control (which improves the quality of the straw obtained) is practiced by 40 breeders (59.7%). The practice of crop rotations (durum wheat-legumes; durum wheat-vegetable

crops) can improve the quality of the soil (Viaud et al., 2018), and is adopted by 32 breeders (45.1%). It should be noted that some of the farmers interviewed experimented with new food rations which had good milk yields (imitations of innovations).

During the pre-survey, some farmers introduced alfalfa cultivation to feed dairy cows and also for fattened cattle. This green fodder is used with other concentrated feed and silage to prevent certain food-borne illnesses in cows.

Certain innovations were introduced by *Boussouf dairy complex*¹, which launched a major agricultural investment in the region, was able to introduce some innovations to the region and even to dairy farming in general. These innovations concern the entire industry, for food, the complex introduced and developed fodder crops (sorghum, alfalfa, corn) irrigated by the hose reel. As they introduced the intensively driven dairy cows using artificial insemination to keep their genetic potential. This complex has also experienced a new organization based on the separation of cows by age and sex and finally a milking parlour equipped to facilitate milking and permanent monitoring of dairy cows.

However, innovations in animal material are not widely adopted, the introduction of modern cows was made by only 23 breeders surveyed because of problems of adaptation to the climatic conditions of the region and the insufficiency of fodder crops or may be the unavailability of the market. Despite the fact that artificial insemination is subsidized by the State in terms of animal seeds and veterinary costs, this technique is little practiced by breeders (only 10 breeders) because of its high failure rate according to the breeders surveyed, which is due to several factors: poor detection of heat by farmers poor quality of animal semen and reactivity of the inseminators.

The introduction of the milking machine is an innovation linked to the size of the livestock, which can reduce the workload of farmers. In our region, it is adopted by 28 breeders (41% of the sample). The innovation concerning the green feeding of dairy cows is adopted by only 12 breeders who cultivate summer sorghum and alfalfa (annual) and 20 breeders use of ensiled green corn (cultivated in the south of the country more than 600 km from the region) supplied by the dairies.

The implementation of the milk collection system by the State in the early 2000s can be considered as an innovation in the organization and process of the dairy sector. Also, it can be considered as a marketing innovation if we refer to the change in marketing mode (from direct to indirect sales). According to Fouko et al., (2011), "The innovation here refers not only to the improvement of milk production processes through the establishment of collection centres or mini-dairies, but also to an organizational structure ensuring the registration of producers in institutionally recognized groups". This innovation is in accordance with the contemporary definition of innovation as "the result of interaction between heterogeneous actors" (Ingrand et al., 2014). Indeed, according to (Callon & Latour, 1990) innovation does not concern an actor or an organization, but rather the interactions between its constituent actors.

For the breeders, this new conception is approached with a lot of hesitation insofar as the two channels, namely traditional and industrial remain. Perrier-Cornet 1986, p.70 qualified this innovation as an "innovation in the tradition" in the sense that the practices oscillate between "ruptures and reproduction of traditional practices". Farmers' attitudes play a key role in the adoption of innovations (Bellon-Maurel & Hayghe, 2016). In our survey, these practices are responded to, for at least, two reasons; the anchoring and rooting with respect to traditional products which is at the origin of the persistence of this sector (known as informal) and, on the other hand, the delays in payment of the dairies cause cash flow problems for the farmers who find themselves forced to sell part of the production via this circuit to have daily cash. Finally, regarding the dairy market in the region, "Market analysis shows the dynamism and complementarity of the sectors that supply the city with local dairy products" (Mian-Oudanang, 2009). Kilelu et al, (2013) point to co-evolution as a useful concept for understanding the complexity of the innovation process, which entails continuous interaction of technical, social and institutional elements.

¹ Private farm: which has invested in vertical integration and mix farming.

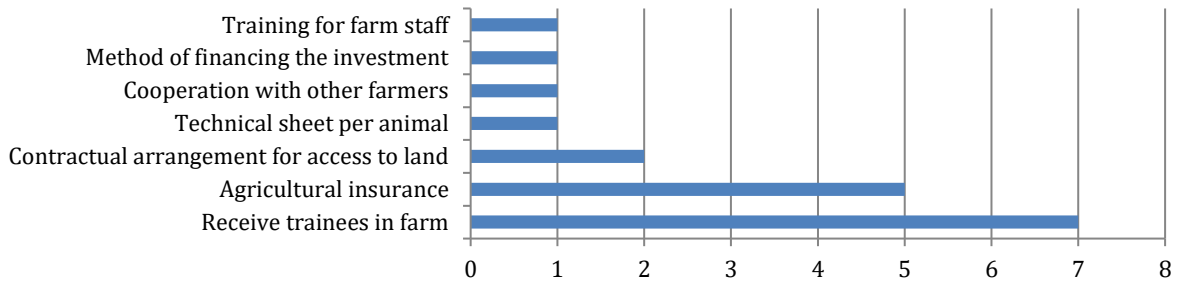


Figure 7 – Organizational and marketing innovations (number).
Source: established from the survey analysis.

Surveys showed a low adoption rate of organizational innovations (Figure 7). This observation can be explained by the absence of the professional organizations (association and cooperatives) in the region. Indeed, out of the 20 innovations proposed, 7 innovations (fig n°) are adopted with very low rates (new financing methods, cooperation with other farmers, monitoring by cows and training of the farm's workforce). Although agricultural insurance is an important guarantee, especially during epidemics (foot-and-mouth disease, brucellosis, etc.), it is weakly adopted by breeders (5 breeders) and often under constraints (projects funded by Youth Employment Agency). The technical sheet per animal (feeding, reproduction and milk production) is practiced by three breeders: one in a traditional way using a notebook and the other two by modern means: the milking parlour and the pedometer (which gives updated information on the cow's state of health). The *Boussouf dairy complex* has also introduced on-farm raw milk analyses (fat, protein test, and antibiotic test).

In our study, we hypothesized that contact with other economic, technical and institutional agents facilitates the dissemination of innovations and their adoption. With the evolution of new technologies of communication, information access is becoming less significant as a constraint to the adoption of innovations (Guerin, 2001).

Although innovation is an interactive process that involves many players both internally and externally environment (Dif & Benziane, 2014) (direct and indirect environment), in our region, most of the contacts established by breeders are personal (especially in weekly cattle markets, where the livestock dealer is a source of innovation), and some administrative extension advices through livestock identification at the veterinary inspection. At the agronomic level, research is constantly developing new production and herd management systems; however, their adoption by stakeholders remains difficult. The production system and the marketing channels seem to be locked around a technological paradigm that is essentially based on past and traditional practices. This configuration can be justified by the theory of path dependency, which justifies these behaviours according to Levi, 1997: "the costs of going backwards are very high. Other options are possible but the anchoring of certain institutional arrangements obstructs a reversal of the initial choice".

Indeed, the absence of technical institutes in the region constitutes a limiting factor for the diffusion of new techniques of breeding. At the level of our study region, we noted the non-existence of the main components of an innovation ecosystem as described by Bellon-Maurel and Huyghe (2016) "An innovation ecosystem includes different actors such as research, applied research, economic actors, as well as training, which plays an important role in adoption processes".

Note that the pilot farm Maazouzi², by its public status, has relations with the Technical Institute for Field Crops (for the cereal intensification program), the Technical Institute for Plant Protection (for the fight against phyto-sanitary diseases) and the National Seed Certification Center (seed development lentils).

² Pilot farm, under public law: its mission is to introduce and disseminate technical innovations.

Relative to the industrial processing, two important dairies have set up credits (these are *GROUZ group* and *Mila-Milk dairy*). The latter have taken the supplier credit initiative, which consists in supplying modern dairy cows (MDC) to farmers. The repayment of credits is spread over several years in order to increase the productive capacities of the region.

To this is added direct investment in milk production with two different forms:

- A partnership between a pilot farm Maazouzi and a private company, with 250 modern dairy cows;
- A private investment (*BOUSSOUF group*), with 500 modern dairy cows and an integrated sector (fodder production).

Adoption of technological innovations in agriculture is a subject of interest for the economist because of its impact on production and income improvement for farmers. In fact, the adoption of technology is proving to be a complex issue that depends on many factors, including local infrastructure (e.g. electricity) and characteristics of the farm and households (e.g. level of formal education and training; some technologies can be applied directly but most require adaptation to local conditions, which includes taking into account the type of farming system used by small operators wishing to adopt new technologies (Tricarico et al, 2020). Nevertheless, the adoption of these innovations still met a resistance among farmers. Knowler & Bradshaw (2007), indicated that many factors explain the non-adoption such as the lack of credit, limited access to information, aversion to risk, inadequate farm size, inadequate incentives associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labour shortages (thus preventing timeliness of operations), chaotic supply of complementary inputs (such as seed, chemicals, and water), and inappropriate transportation infrastructure.

Akrich et al., 1988, have shown that the success of an innovation can be explained in two different ways: either by its intrinsic qualities, which make its adoption very rapid, or by the conviction of certain individuals who actively participate in advancing its dissemination. For their part, Fortun-Lamothe and Davoust (2017) set out three conditions that foster the emergence of innovations within a system: knowing how to innovate (skills, techniques, knowledge), being able to innovate (structure, organization, management, resources), and wanting to innovate (strategy, vision, state of mind).

In addition, the origin of the innovation (endogenous and exogenous) and its nature (product, process, marketing and organization) plays a crucial role in the adoption of innovations. Indeed, the fact that innovations are exogenous is sometimes cited as a factor limiting the adoption of innovations (Ingrand et al., 2014).

According to the Figure 8, the lack of qualified personnel, risk of return on investment, the size of the market, the insufficiency of State aid, and the difficulty of access to finance, land ownership, climate variability, cost of inputs, access to water resources are the constraints that prevent the adoption and emancipation of innovations in our region of study.

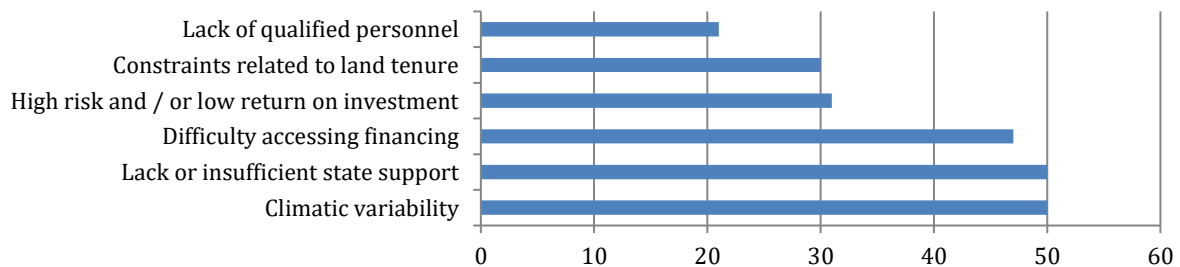


Figure 8 – The constraints of innovation (Source: established from the survey analysis)

According to the interviewed, the brakes on innovation in this sector are primarily climatic and financial. Land ownership (guaranteed for banks) poses a serious problem blocking farmers' access to financing for innovations and therefore they continue to have low per capita yields.

CONCLUSION

To achieve the main objective of this sector, namely increasing the quantities produced, the public authorities have set up several incentive measures for breeders (price subsidies for production and consumption, support for equipment and investments).

All of these innovations have made it possible to promote local production, even though it is still very limited. Indeed, these measures, which constitute innovations, did not affect all categories of farms, especially those of small size, and are not durable (removal of investment support since 2014 for financial considerations).

Regarding the process of adoption and dissemination of innovations, the majority of breeders do not adopt new techniques because of the high risk, linked to investment, poor mastery of farming techniques and their financial inability to bear the induced expenses.

Access to bank financing remains the major obstacle to investment in this sector for several reasons (technical, guarantee, and above all religious). The only innovations adopted are those whose cost is borne in whole or in large part by the State, as well as innovations brought by the herders themselves or via informal transmission processes (market and word of mouth). It emerges that the implementation of the milk collection system coupled with the various forms of subsidies and innovations have strengthened the structure of the sector by promoting beneficial interactions between actors. On the organizational and social level, these innovations have helped to restructure the relationships between the players in the sector, which has, as a result, improved the living conditions of the populations not only at the local level, but also at the national level.

The contribution of stakeholders located upstream and downstream of milk production, remains weak and little incentive for innovation. Note, buyers of raw milk (especially dairies) are not very demanding in terms of quality, which does not encourage breeders to innovate in the conditions of breeding.

On the institutional level, agricultural extension through its actors (Communal Extension Agents, Chamber of Agriculture, Extension Institute, Artificial Insemination Centre, and Technical Breeding Institute) contributes weakly in the process of dissemination of innovations. Indeed, the main source of innovation remains through farmers (word of mouth) and the cattle market (meeting place).

On the macroeconomic level, a major obstacle to innovate and to incentive is the ease of substitution of local production by imports of milk powder, subsidized by producer countries and by the Algerian public authorities. In addition, the difficult access to water in *Oued Athmania* for the irrigation of fodder crops limits the adoption of fodder crops with high fodder values (clover, alfalfa, corn, and sorghum). In the end, the dynamics of innovation at the level of the study region inspire two conclusions: the role of the State and the innovative capacities of the actors. Despite all that is said, the state continues to play a key role in the improvement and promotion of the dairy sector in Algeria. On a second level, as a consequence of the first conclusion, actors are more or less receptive to innovations whose cost and risk are moderate whether they are internal or external.

In order to improve the adoption of new farming techniques, we propose to focus on improving productivity per dairy cow. This goal could be achieved by improving the conditions of breeding by the breeders and especially the implication of the industrialists for the improvement of the quality of the product obtained.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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