

The adoption of technical and organizational innovations and their impacts on the dairy sheep breeding in Tunisia

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1. Introduction

Raising dairy sheep in Tunisia dates back to the colonial period during which new settlers brought in two Italian breeds: the Sardinian and the Comisana races from southern Italy. The crossbreeding of these two races gave birth to a unique dairy sheep breed in Tunisia: the so called Sicilo-Sarde sheep (Khaldi and Farid, 1981). The rearing of this breed is concentrated in the hills of northern Tunisia, especially in Beja and Bizerte. A cheese tradition was developed in this area. The milk production is limited, but it is entirely used for the industrial or artisanal cheese making. Djemali *et al.* (1995) estimated the average milk production to equal 72 kg/ewe/lactation with an average of 124 milking days and a suckling period of 114 days. Over several years, the total milk production has stagnated at nearly 1700 T/year (Kayouli, 2006). The low productivity is mainly due to an extensive flock management (Snoussi, 2003). To face this situation, efforts have been made to improve the breed's performance and to

Abstract

In Tunisia, the size of the dairy Sicilo-Sarde sheep population has decreased by 90%. Its productivity has stagnated at around 70 litres/ewe/lactation over the last decade. The milk production is totally used for cheese making. The objective of this work is to identify the innovations adoption and their impacts on flock performance. Two types of innovations are considered: technical innovations (food supplementation, early weaning and crossing with Sardinian breed) and organizational innovations (membership in breeders' associations). The adopted methodology is based on an exhaustive survey. Two milk production levels were selected for the analysis: a «class 1» (production level > 70 litres/ewe/lactation) and a «class 2» (production level ≤ 70 litres/ewe/lactation). The results show that, whatever the milk production level, the innovation adoption rates of food supplementation and early weaning are still low, but they remain higher in class 1. The same conclusion is true for the organizational innovation which seems to slightly improve the flock performance. The farmers membership to the breeders' association allowed an increase in the milk price and reduced the monopoly imposed on the sector.

Key words: Tunisia, dairy sheep, technical innovation, organizational innovation.

Résumé

En Tunisie, l'effectif des ovins laitiers de race Sicilo-Sarde a chuté de 90%. La productivité de cette race a stagné autour de 70 litres/brebis/lactation au cours de la dernière décennie. Le lait produit est totalement utilisé pour la fabrication du fromage. L'objectif de ce travail est d'identifier l'adoption des innovations et leur impact sur les performances des troupeaux. Deux types d'innovation sont pris en considération: innovation technique (complémentations alimentaires, sevrage précoce et croisement avec la race sarde) et innovation organisationnelle (adhésion à des associations d'éleveurs). La méthodologie adoptée se base sur une enquête exhaustive. Deux classes de niveaux de production enregistrés ont été retenues pour l'analyse: > 70 litres/brebis/lactation et ≤ 70 litres/brebis/lactation. Les résultats montrent des taux d'adoption encore faibles de la complémentation alimentaire et du sevrage précoce et ce, quelque soit le niveau de production, mais ils restent en tout cas plus élevés pour la classe 1. Il en est de même pour l'innovation organisationnelle qui semble améliorer légèrement les performances des troupeaux. L'adhésion de ces éleveurs à une association a permis d'augmenter les prix du lait et de réduire le monopole imposé sur le secteur.

Mots clés: Tunisie, ovins laitiers, innovation technique, innovation organisationnelle.

protect it from extinction. Indeed, the number of heads has decreased by almost 90% (Mohamed *et al.*, 2007). Scientific research in this area demonstrated an important role of early weaning in increasing the milk yield. Khaldi (1987) showed that early weaning of lambs at 42 days, compared to that carried out at 90 days, significantly increases ($P < 0001$) the milk yield in both single suckling ewes (82 vs. 62 l) and twin suckling ewes (118 vs. 66 l). The average of the total milk yield (residual + milked) may reach 176 litres in the case of weaning at 90 days (Mohamed *et al.*, 2008). An adequate feeding management with a concentrate supplementation at the appropriate periods could also increase the milk yield (Khaldi, 1981, Rouissi, 1989, Al Jassim *et al.*, 1999, Bocquier *et al.*, 2004). Locally, an Association of Sicilo-Sarde Breeders (AESS) was created in the Beja region in 2002, in order to enhance

livestock products and ensure the sustainability and organization of the entire dairy sheep sector. The main objectives of the association, as stated in its «Director Plan», for the period 2005-2010, are to increase the association members' total herd size from 10,000 to 30,000 female units and to improve the milk yield/ewe/year in order to pass from 90 litres to 150 litres (Sâadoun, 2007). Based on the fact that

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these actions constitute innovations for the farmers and that research in this domain in Tunisia was limited to purely zootechnical aspects, technical and socio-economic analyses of the innovations' impact in dairy sheep farming are now needed. This article aims to:

1) identify levels of the innovations adoption, divided into two types: technical and organizational;

2) analyze their impact on the Sicilo-Sarde breed performances and on the whole sector; and,

3) determine the reasons for innovations non-adoption.

2. Research methodology

Starting with the assumption that low dairy performances are related to inappropriate herd management, an exhaustive investigation was conducted during in 2006/2007. One hundred five farms were surveyed, evenly distributed between the regions of Bizerte and Beja. The investigation addressed aspects related to dairy sheep activity, its history and its place in the production system, herd management, milk production and its destination (sales, processing and marketing), and membership to AESS.

A classification of farms has been developed on the basis of the average milk yield. Each class is characterized by different adoption levels of technical and organizational innovations. Available technical innovations provided by research and used for the analyses are:

- Food complementation during critical periods of mating (400 g/ewe/day) and before lambing (400g/ewe/day);
- Early weaning of lambs (≤ 90 days old).

The adoption of organizational innovations consists of the farmers' membership to AESS.

The measurement of the innovations adoption is based on the calculation of the adoption rate (Slim Khaldi, 2003):

The measurement of the impact of technical innovations is based on the

$$\text{Adoption rate} = \frac{(\text{number of farms adopting the innovation})}{(\text{total number of farms})} * 100$$

comparison of productivity in the surveyed dairy sheep farms with respect to the research results obtained in an experimental station in northern Tunisia, under optimal conditions of production. An implementation rate of research results (IRRR) is calculated (Slim Khaldi, 2003):

$$\text{IRRR} = \frac{(\text{average milk yield/ewe/lactation}) \text{ recorded on the farms}}{(\text{average milk yield/ewe/lactation obtained in the experimental station})} * 100$$

explained by technical and socio-economic variables related to the farm and its environment.

3. Results and discussion

3.1. Characterization of dairy sheep breeding on surveyed farms

3.1.1. Place of the dairy sheep breeding

A total number of 19,126 female units, 84% of which are purebred, was identified on surveyed farms. The purebred dairy sheep breeding is a main agricultural activity on public farms at a rate of 70% (57% are located at the Beja region). In the public sector, 6,126 female units were listed (Table 1). The private sector is represented by 95 farms holding 13,000 female units of which 68% are counted in Beja. Rearing purebred dairy sheep is a main agricultural

Table 1 – Characterization of surveyed farms.

	Total number of farms	Public sector			Private sector		
		number of farms	Beja	Bizerte	number of farms	Beja	Bizerte
Number of farms	105	10	5	5	95	45	50
Number of animals (female units)	19126	6126	2497	3629	13000	8540	4160
Main agricultural activities (%)							
	Total number of farms	number of farms	Beja	Bizerte	number of farms	Beja	Bizerte
- Purebred dairy sheep breeding	58	70	57	45	53	78	22
- Crossbred sheep breeding (Sicilo-Sarde/Barbarine)	42	0	0	0	47	13	87

Source: Survey results

activity for almost half of farms (53%), of which 78% are located in Beja. However, the crossbred dairy sheep breeding (Sicilo-Sarde breed x Barbarine local breed) for meat and milk production is very common and remains the main activity in 47% of private farms, 87% of which are located in Bizerte.

3.1.2. Milk performances

On all surveyed farms, the average milk yield (AMY) is of about 78 litres/ewe/lactation during an average of 165 milking days (Table 2). It reached 83 litres in the region of Beja for a milking period of 174 days.

A classification of dairy sheep farms was carried out according to the average milk yield (AMY). Two classes have been identified (Table 3):

- «Class 1»: AMY > 70 litres/ewe/lactation (49% of the total number of farms)
- «Class 2»: AMY \leq 70 litres/ewe/lactation (51% of the total number of farms).

In «Class 1», the farms' number is divided into 60% and 40% in Beja and Bizerte, respectively. The average milk yield/ewe/lactation is 91 litres for an average milking period of 180 days (Table 3). In the same class, the public sec-

Table 2 – Milk performances on surveyed farms.

	Average milk yield (AMY) (litres/ewe/lactation)			Milking period (days)		
	Total number of farms	Beja	Bizerte	Total number of farms	Beja	Bizerte
Overall mean	78	83	74	165	174	157
Standard deviation	17	18	16	44	42	44

Source: Survey results

tor's performance is slightly higher than the one of the private sector. This is due to the longer milking period. In the second class (33% and 67% farms located in Beja and Bizerte respectively), the milking duration is relatively shorter (150 days on average) than the one in the first class. This explains the lower milk performances in the second class (64 litres/ewe/lactation). Slight differences were observed between regions falling into the same class.

3.1.3. Levels of adoption of technical and organizational innovations

By adopting the hypothesis that the production variability between «class 1» and «class 2» is related to the innovations implementation, the calculated adoption rate (Table 4) shows that in «class 1» the flushing and steaming food complementation techniques in critical periods are respectively adopted by 47% and 55% of the surveyed farms. The quantity of food provided to the animals is still insufficient (300g/ewe/day). As for «class 2», there are lower rates of adoption (25% and 44% respectively for the two food supplementation techniques). The early weaning of lambs is practiced by nearly half of farms in «class 1», against 19% of farms in «class 2».

Table 3 – Classification on farms according to their milk production level.

	Class 1						Class 2					
	AMY (litres/ewe/lactation)			Average milking period (days)			AMY (litres/ewe/lactation)			Average milking period (days)		
	Total number of farms	Beja	Bizerte	Total number of farms	Beja	Bizerte	Total number of farms	Beja	Bizerte	Total number of farms	Beja	Bizerte
Overall mean	91	85	89	180	180	170	64	64	65	150	154	148
Standard deviation	14	13	15	25	28	46	5	6	4	43	44	44
	Private sector		Public sector		Private sector		Public sector		Private sector		Public sector	
Overall mean	91		94		175		181		64		*	
Standard deviation	15		12		46		12		5		*	

Source: Survey results

Generally speaking, the levels of adoption of technical innovations are higher in the region of Beja. In «class 2», the steaming technique is adopted by the same percentage of farmers (44%) in Bizerte and Beja. Indeed, animals of this class are generally crossbred in order to produce vigorous lambs at birth and then to increase meat production as main objective.

Taking into account the sectors, the rate of adoption of

Table 4 – Rates of adoption of technical innovations per class (%).

	Class 1			Class 2		
	Total number of farms	Beja	Bizerte	Total number of farms	Beja	Bizerte
- Flushing	47	48	44	25	38	19
- Steaming	55	48	66	44	44	44
- Early weaning (≤ 90 days old)	49	69	44	19	31	13
		Private sector	Public sector	Private sector	Public sector	
- Flushing		47	100	25	*	
- Steaming		55	100	44	*	
- Early weaning (≤90 days old)		17	100	19	*	

Source: Survey results

technical innovations in «class 1» is 100% for public farms and it does not exceed 17% for early weaning on private farms. Food supplementation is practiced by almost half of private farms belonging to this class. These results show that low performances of the Sicilo-Sarde breed are linked to the low adoption rates of technical innovation on private farms, especially as for the early weaning of lambs. Although the public sector records higher adoption rates, milk performances remain limited.

Concerning the organizational innovation, more than half of the farms belonging to «class 1» (55%) are members of AESS, and 46% of them belong to the private sector. This rate reaches 90% on public farms. Breeders' membership to «class 2» is only 31% (Table 5). This could be explained by the fact that farmers are not accustomed yet to this new concept of «association».

3.2. Impact of innovation adoption

3.2.1. Technical innovations

3.2.1.1. Comparison to the research results

Research results (RR) obtained by the application of early weaning (prior to three months) and the application of food supplementation during critical periods (see above)

Table 5 – Rates of adoption of organizational innovations (Membership to AESS) and effects on the production level (%).

	class 1			class 2		
	Total number of farms	Beja	Bizerte	Total number of farms	Beja	Bizerte
	55	66	39	31	63	16
		Private sector	Public sector		Private sector	Public sector
		46	90		31	*

Source: Survey results

Table 6 – Comparison of the research results with the surveyed farms performances.

AMY deviation between RR and farm performances (liters)	Class 1		Class 2	
	Beja	Bizerte	Beja	Bizerte
	83	87	112	111
	Private sector	Public sector	Private sector	Public sector
	88	82	112	*
Implementation rate of research results (IRRR) (%)	Beja	Bizerte	Beja	Bizerte
	53	50,5	36,4	37
	Private sector	Public sector	Private sector	Public sector
	53	38,5	36,4	*

Source: Survey results

gave an average milk yield of 176 liters/ewe/lactation (normal + residual milk). The comparison of performances recorded on the surveyed farms with the RR shows significant differences of 85 liters and 112 liters respectively for «class» 1 and «class 2». IRRR stands at 52% for «class 1» and it is only 36.4% for «class 2» (Table 6). According to the region, this analysis made clear that there is no great variability, but a slight superiority of Beja with respect to Bizerte is maintained.

Even if the performance is better in the case of «class 1», it still remains below the potential of the breed that can reach 181 kg (milk trait + residual milk) in the case of the application of semi-weaning at 45 days of age, and of the steaming using a quantity of concentrate of 400 g/ewe/day (Mohamed *et al.*, 2008).

3.2.1.2. Explanatory factors

The higher IRRR registered in «class 1» (AMY > 70 liters/ewe/lactation) could be explained by several factors related to the farmer himself, the production system, the herd

Table 7 – Characterization of farming systems according to the production level.

	Class 1		Class 2	
	Average	S. deviation	Average	S. deviation
Criteria related to the farmer				
Average age (years)	46		49	
Illiteracy rate (%)	47		85	
Criteria related to the production system				
	Average	S. deviation	Average	S. deviation
Herd size (FU)	270	319	99	98
Total Cultivated Area (TCA) (ha)	234	660	19	29
Pasture (ha)	36	59	13	16
Forage area (ha)	16	24	3	4
Criteria related to the herd management				
Crossbreeding of the Sicilo-Sarde breed with other breeds		38		65
Animal housing in good situation (%)		62		23
Average culling rate (%)		12		6
Use of specialized manpower (%)		60		27
Criteria related to the farm socio-economic environment				
Problems of milk marketing		12		30

Source: Survey Results

management, and to the farm socio-economic environment, all factors that are far better than those in «class 2» (Table 7). Indeed, in «class 2», the average herd size is relatively low, with an average of 99 female units (FU) against 270 FU in «class 1». The Total Cultivated Area (TCA) is on average 19 hectares (ha) in «class 2» but reached 234 ha in «class 1». The pasture and forage areas reserved to dairy sheep farming are respectively 13 and 3 ha. They are multiplied by nearly 3 and 5 respectively in «class 1». Herds are characterized by the dominance of crossbred animals (65%). The culling rate is very low (6%) with respect to «class 1» (12%). Animal housing is 77% for the «class 2» farms, partially covered, made of metal sheets and trees twigs, then exposing animals to winter cold temperatures and to summer high temperatures. In this class, there is family-run farming system where the shepherd is a member of the family (Mohamed *et al.*, 2007). Only 27% of farms in this class use specialized manpower (60%). Furthermore, the farmers' education level remains low (83% are illiterate). Problems of milk marketing are expressed by one third of farmers in this class.

3.2.2. Organizational innovation

During recent years, several attempts have been undertaken in order to rehabilitate the dairy sheep sector in Tunisia. The main one is the creation of AESS in the region of Beja. A «Director Plan» of the association has been established for the period 2005-2010. The main objectives of this plan are to increase the combined member's herd size from 10,000 to 30,000 FU and to improve the milk yield/ewe/year from 90 liters to 150 liters (Sâadoun, 2007). The collaboration between AESS and research institutions is an important element to ensure the sustainability of the dairy sheep industry. Several actions were taken in order to motivate farmers to become members of the association, control the performance and to improve pastures in the framework of programs managed by the OEP (Office of Livestock and Pastures), through the organization of training and information days in collaboration with the Animal Production Services, the Higher Education and the Scientific Research Institutions, in order to prepare and distribute data sheets for a better flock management.

The negotiations of the milk price with the government services led to its increase from 1,100 DT to 1,440 DT. A growth rate of about 31% was registered (Mohamed, 2008). This has helped reduce the monopoly imposed by the only cheese industrial processing company in the country. An artisanal processing unit with an average capacity of 300 liters/day was established in the region of Beja in 2007, whereas farmers used to process their milk individually or sell it to a cheese-making industry. The creation of this unit ensures higher milk prices to the AESS members. The ricotta and the artisanal cheese produced in this unit are sold at 7,500 DT and 3,800 DT instead of 3,700 DT and 2,800 DT which means an increase of 103% and 36% respectively. With the collaboration of Research Institutions, Animal Production Services of the OEP and AESS, semen of Italian rams (Sardinian breed) was imported in order to reduce in-

Table 8 – AMY (litres/ewe/lactation) according to the adoption of organizational innovations.

	Class 1		Class 2	
	Average (litres/ewe/lactation)	S. deviation	Average (litres/ewe/lactation)	S. deviation
Members of AESS	94	14	62	4
Other farms	89	14	65	5

Source: Survey Results

breeding of ovine dairy herds by using artificial insemination. This has enabled 7 farmers, who are members of AESS, to inseminate 1,600 Sicilo-Sarde ewes. This insemination led to higher fertility rates (59%) and higher prolificacy rates (156%) (Sâadoun, 2007) compared to those presented in the literature (90% and 144% for the fertility rate and the prolificacy rate respectively) (Khaldi and Farid, 1981).

The increase of 5.6% in milk average yield which reached 94 liters/ewe/lactation instead of 89 liters/ewe/lactation among the AESS members of «class 1» is already an achievement (Table 8). In «class 2», the adoption of organizational innovation still does not show differences in milk performance since animals are generally used for mixed purposes (milk and meat). In this case, farmers join AESS primarily to receive financial aids, grants, etc.

4. Conclusion

Our research results show that the low performances of the dairy sheep breed in Tunisia, the «Sicilo-Sarde» race, are related to the low rates of technical and organizational adoption, especially in the private sector and also in the public sector, even if the latter records higher adoption rates. Technical and organizational innovations seem to slightly improve the herd performances; however, the average milk yield of the Sicilo-Sarde breed remains below its real potential as demonstrated by the research results.

The membership of farmers to AESS is limited even in the case of «class 1» (>70 liters/ewe/lactation). Opportunities exist for improving the Sicilo-Sarde breed productivity, particularly in this class, based on the education of farmers about the importance of practicing a severe culling, on the use of adequate, balanced and good quality animal feeding and on early weaning of lambs. For «class 2» (≤ 70 liters/ewe/lactation), the situation is more difficult because animals reared by small farmers are generally crossbred. However, they also constitute a vital source of income for these farmers.

Saving the Sicilo-Sarde breed from extinction requires the urgent setting up of a breeding program and a greater awareness among farmers especially through the action of associations that should be supported by grants, the construction of facilities for technical training of farmers, the organization of milk collection and through the establishment of other industrial processing units. Banning the slaughtering of Sicilo-Sarde females and fostering the breeding of this race through donations of small flocks are also essential.

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