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## Techno-Economics Assessment of Genetic Improvement via Artificial Insemination in Dairy Cattle in Dakahlia Governorate

Ahmed E.E. Elmowafy

Agricultural Economics Research Institute, Agricultural Research Center, Egypt

### ABSTRACT

In Egypt, the importance of increasing the domestic production of milk via genetic improvement stems from the lack of horizontal expansion in cattle population due to the limited feeds production because of water and agricultural land resources constraints. Dakahlia is the second highest governorate for rates of cattle milk productivity, estimated by 1.1, 2.8 and 5 t head<sup>-1</sup> for Baladi, hybrid and foreign breed respectively in the average overall the period (2010-2014). Therefore, this research aims to study the merits and the feasibility of genetic Improvement via the Artificial Insemination (AI) in dairy cattle in Dakahlia governorate to extend the successful applying of genetic improvement program in this governorate and the other governorates; as a stress on the importance of increasing the domestic production and the income of dairy milk in Egypt through investments in AI. A statistical analysis and mathematical economic model were designed and implemented by using Excel and SPSS programs software to study some factors affecting milk production of dairy cattle herds; then, estimates the Extra Internal Rate of Return (EIRR) as a criterion of the feasible economic along the full productive life of the daughter of the cow served by AI of the concerned sire's semen. The data of the cow milk productive and reproductive performance traits were collected from the questionnaire has designed and implemented through a stratified random sample survey of the commercial farms are specialized in the investment of hybrid dairy cattle in Dakahlia governorate in the year 2014. The results showed the effects of every order of the season of calving, the lactation season in the year and the age at the first calving are statistically significant at the confidence level less than 0.10. As, the economic criterions indicate the most probable Extra Internal Rate of Return (EIRR) is around 26, 31 and 33% for small, medium and large farm scale, respectively. The highest negative effect on EIRR for the three farm scales is the increase of feeding costs (It drops by about 7, 7 and 6%), followed by the negative effect of the increase of number of services for conception (EIRR decreases by around 6, 6 and 5%). Lastly, the negative effect of the decrease of dairy cow milk price (EIRR diminishes by about 4, 3 and 3%). Generally, the genetic improvement investment via AI in dairy cattle in Dakahlia governorate is high feasible.

**Key words:** Techno-economics assessment, genetic improvement, artificial insemination, dairy cattle

### INTRODUCTION

There are evidences that Egypt has a comparative advantage in milk production, rather than red meat production, (Soliman and Mashhour, 2002, 2015). Therefore, the feasible development plan supposed to give the first priority for increasing the domestic milk supply rather than red meat production, particularly that, import prices of fresh milk and dairy products are too high as highly perishable food commodities (Soliman and Basioni, 2012). The importance of increasing the

domestic production of milk in Egypt via genetic improvement stems from the lack of horizontal expansion in cattle population due to the limited feeds production because of water and agricultural land resources constraints. In addition, there is high competition between human demand for food production and livestock demand for feed production from such limited resources and Egypt has almost no natural range land (Sharaf *et al.*, 1987).

Above all, the milk yield of domestic cattle is, below the world average, while there is a deficit in domestic milk production to cover the Egyptian effective demand (Soliman, 2008). Accordingly, the only possible approach for livestock development in Egypt is to fix the stock capacity within the balanced number with feed availability and focusing on the vertical expansion in yield, particularly, milk yield (Soliman, 2007).

On the other hand, in Egypt the numbers of livestock's heads estimated by 10 millions heads (5 million heads of the cattle approximately). The value of livestock products (meat and dairy milk) was amounted to 93.1 LE billions, this represented about 36% from the total agricultural income; the value of domestic milk around 26% from the value of this livestock products in the average overall the period (2010-2014) (MALR., 2014a).

Cattle and buffaloes were produced about 99% (6.3 million t year<sup>-1</sup> approximately) of the total annual domestic dairy milk, about 31% of this milk production from cattle in the average of the same period.

Although, Dakahlia governorate held around 10 thousands of the dairy cattle's heads represented about 4% of the total number of dairy cattle's heads in Egypt, they produced 2.4 million t year<sup>-1</sup> approximately, contributed around 6% of the total annual dairy cattle's milk in Egypt; Dakahlia is the second highest governorate for rates of cattle milk productivity, estimated by 1.1, 2.8 and 5 t head<sup>-1</sup> for baladi, hybrid and foreign breed respectively in the average overall the period (2010-2014), (MALR., 2014b). This is due to the interest of many dairy cattle's breeders in this governorate to implement genetic improvement programs mainly via the artificial insemination AI. Four main centers present in Dakahlia that provide AI services for cattle and buffaloes to serve this governorate and other neighborhood governorates.

Therefore, this research aims to study the merits and the feasibility of genetic improvement via AI in dairy cattle in Dakahlia governorate as a stress on the importance of increasing the domestic production and the income of dairy milk in Egypt through investments in AI. This is through the following sub-goals:

- Determining the important factors affecting milk production of the cattle herds in sample of dairy cattle farms in Dakahlia governorate
- Calculating the Extra Internal Rate of Return (EIRR) and its sensitivity analysis, as a criterion of the feasible economic of AI in dairy cattle in Dakahlia governorate

## **MATERIALS AND METHODS**

In this study, a statistical analysis and mathematical economic model were designed to implementing by using Excel and SPSS programs software to study some factors affecting milk production of the random sample of dairy cattle herds; then, estimates the Extra Internal Rate of Return (EIRR) as a criterion of the feasible economic along the full productive life of the daughter of the cow served by AI of the concerned sire's semen. Then, proceed to the sensitivity analysis of the most probable estimates of EIRR due to the changes in some important techno-economic variables.

The data of the cow milk productive and reproductive performance traits was collected from the questionnaire has designed and implemented through a sample survey in Dakahlia governorate in the year 2014.

The sampling method was a stratified random sample of the commercial farms are specialized in the investment of hybrid dairy cattle, Baladi (Domestic) crossed by Friesian and Baladi-Browen. The small size or scale farms (less than 25 heads of dairy cows), the medium scale farms (25-50 dairy cows) and the large scale farms (more than 50 dairy cows) were represented the three strata of the field sample. Two farms were randomly choice from each stratum. The total sample size is 212 heads of dairy cows allocated on six farms.

**Statistical analysis and economic evaluation:** As, livestock is a dynamic investment model of production not as ordinary investment types that characterized by depreciation pattern and treated via a systematic annual inflow of costs and outflow of revenues, it needs special financial treatment, (Soliman, 1985). The time horizon of the project life span is determined by the production cycle of the dairy cow and its daughters. The reproductive criteria are all functions of time. The major reproductive criteria are age at first calving, service period and calving interval. The milk yield level and persistency period requires adjustment for cow age and milking season order (Mashhour, 1995). Feed efficiency is also an important techno-economic variable that affect the milk productivity and profitability and represents the highest proportion of the operation costs of dairy cattle farms (Blake, 1979).

**Statistical analysis:** The dairy cattle production of milk determined by particular performances are mainly the service period (the period between calving and conception of the cow), the average number of services required for conception, the calving interval (the sum of the service period and gestation period or a lactation period and dray period) and some of other genetic and non-genetic factors. Subsequently, to study these factors affecting milk production of the cattle herds in the research sample, data was analyzed through the experimental design, using MANOVA by General Linear Model (GLM) technique using SPSS program. The following full model was used:

$$Y_{ijmLk} = \mu + Si + Dij + C_m + P_L + A_k + e_{ijmLk}$$

Where:

$Y_{ijmLk}$  = Milk yield's observation of the hybrid cow " $ijkLm$ " in the research sample

$\mu$  = Overall mean of milk yield

$Si$  = Random effect of the concerned sire's semen "i". The breeds of sire's semen are Friesian, Friesian-holesten and brown

$dij$  = Random effect of the cow (dam) "j" nested a random effect of the sire "i"; Baladi-Friesian and Baladi-Brown

$C_m$  = Fixed effect of the mature order of the calving "m", 1<sup>st</sup>-5<sup>th</sup> season

$P_L$  = Fixed effect of the season of the lactation season "L", Autumn, Winter, Spring and Summer

$A_k$  = Fixed effect of the age at first calving "k", three categories

The errors in the model assumed are independently distributed according to a normal distribution with zero mean and  $\sigma^2$  (unknown but fixed variance).

**Economic evaluation:** The cash flow of the investment analysis, as a stream of both inflows (costs) and outflows (revenues) was not the classical one that changes annually, due to the nature of reproductive cycle of dairy cattle which is identified by variables that are measured in days and months. The additives on investment costs in this research, was the values of the AI from a certain sire's semen and only considered operating costs were the feed costs to cover the cow's body and productivity needs. In addition, the revenues are generated from the improved milk yield of the daughters of the inseminated dam from the concerned breeding sire. It is a potential quantity of milk which is expected to be added to the average yield of his daughters; that called the "Expected Selection Difference of the semen". Thus, the following mathematical economic model can use:

$$EIRR = r \sim \sum(QPm (1+r)^{1/t}) - \sum((nP_s + Df) (1+r)^{1/t}) = 0$$

Where:

EIRR = Extra Internal Rate of Return with reason AI of cows, which reflect the interest rate of genetic improvement investment in dairy cattle in the determined production period (%)

The first term is the discounted difference between total returns of milk production with reason AI of cow in the year "t" (LE); it represents the extra total returns overall the production.

The second term is the discounted difference between total breeding costs with reason AI of cow in the year "t" (LE).

Q = Estimation of improved quantity of milk yield for the one cow in the average overall difference between the daughter's milk yields and the dam's milk yields in the year "t" (kg)(\*)

Pm = Average of a cow dairy milk price in the year "a" (LE/kg)

t = The year's number through the investment period

n = The average number of semen units for the cow in the year "t"

P<sub>s</sub> = The average price per unit of semen of the concerned sire in the year "t" (LE)

Df = The difference between feeding costs with reason the high milk generating of hybrid cow in the year "t" (LE)

**Model's assumptions:** (1) The number of hybrid cows in the investment enterprise is 10, 50 and 100 heads for the three farm sizes in the research sample, (2) The base year is 2014 and the investment period expanded to 10 years, as the outflows of the genetic investment cover the five successive milking seasons of a daughter of the hybrid dairy cow served by the concerned sire's semen, (3) The quantity of milk yield of the cow has corrected by the parity (as the hundred percent of milk yield means) of a cow maturity or the season of calving (i.e., age at calving), the parity of the season of lactation and the parity of the age at a first calving in, (4) The estimation of improved quantity of milk yield for the cow's head is approximately 791.8 kg, (5) The average number of services for conception is 2 services and (6) The average price of the semen per unit is 150 LE, whereas the average farm gate price of cow milk is 3 LE in the base year.

## RESULTS AND DISCUSSION

The results of GLM model used to explain some of genetic and non-genetic factors affecting milk yield in the research sample shows that the overall mean for milk yield in the present research was

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(\*) These means were estimated from the stratified sample estimator of mean

Table 1: Results of F test and p-value in MANOVA, Duncan test and the parities of some genetic and non-genetic factors affecting milk yield in the research sample

Factors	Groups		
	1	2	3
<b>Order of the season of the calving</b>			
1st	3223.4 (77.5%)		
2nd		3751.2 (90.2%)	
3rd			3995.2 (96.0%)
4th			4160.0 (100%)
5th			4134.1 (99.4%)
F = 196.7 p-value (sig.) = 0.05	1.00	1.00	0.23
<b>Lactation season in the year</b>			
Autumn	3895.2 (96.6%)		
Winter	4032.3 (100%)		
Spring		3688.4 (91.5%)	
Summer		3579.6 (88.8%)	
F = 316.4 p-value (sig.) = 0.06	0.38	0.35	
<b>Age at the first calving</b>			
24-<30	3050.3 (100%)		
30-<33		3102.7 (101.7%)	
33-36		3112.4 (102.0%)	
F = 201.5 p-value (sig.) = 0.07	1.00	0.17	

\*Milk yield mean by kg, \*\*Percents in brackets are the correction factors or the parities, Sig: Significant (Source: Results of the sample data was applied by using SPSS)

Table 2: Prediction of most probable extra economic rate of return, sensitivity analysis and changes from the most probable rate as a simulation of the three farm scales in the sample

Variables	Small farm scale (10 heads)		Medium farm scale (50 heads)		Large farm scale (100 heads)	
	EIRR (%)	Change (%)	EIRR (%)	Change (%)	EIRR (%)	Change (%)
Most probable level of all variables	26.3	-	31.1	-	33.2	-
One time increase in the number of services for conception	20.4	-5.9	25.0	-6.1	27.8	-5.4
Increase in feeding costs by 10%	19.3	-7.0	24.5	-6.6	27.4	-5.8
Decrease in dairy cow milk price by 10%	22.7	-3.6	28.4	-2.7	30.6	-2.6

EIRR: Extra internal rate of return (Source: Calculated from the mathematical economic model)

3872.3 kg. Whereas, the effect of each sire's semen and dams on the milk yield are statistically insignificant; the effects of every the order of the season of calving, the lactation season in the year and the age at the first calving are statistically significant at the confidence level less than 0.10. These results agree with the results was reported by Mohsen *et al.* (1999) and Tawfik *et al.* (2000).

The mean for milk yield, the confidence level and the parity of every of those factors (which the quantity of milk yield can modify by there) are represent for every category (Table 1).

The results of the economic criterions indicate the most probable Extra Internal Rate of Return (EIRR) is around 26, 31 and 33% for small, medium and large farm scale, respectively (Table 2).

Sensitivity analysis of the EIRR towards undesirable deterioration in reproductive performance of the dams would affect negatively genetic investment return. The one time increase in the number of services for conception would decrease the EIRR to about 20, 25 and 28% for the three scales as the same arrange. The increase in feeding costs by 10% reaches the negative impact on EIRR to around 19, 25 and 27% for small, medium and large farm scale respectively. Also, the decrease in the cow milk price by 10% tends to decrease the EIRR amounted to 23, 28 and 31% for the three scales as the same arrange. These results are near with the results were reported by Soliman and Mashhour (2015).

Therefore, the highest negative effect on EIRR for the three farm scales is the increase of feeding costs (It drops by about 7, 7 and 6%), followed by the negative effect of the increase of

number of services for conception (EIRR decreases by around 6, 6 and 5%). Lastly, the negative effect of the decrease of dairy cow milk price (EIRR diminishes by about 4, 3 and 3%). Generally, the genetic improvement investment via AI in dairy cattle in Dakahlia governorate is high feasible.

## **CONCLUSION**

The order of the season of calving, the lactation season in the year and the age at the first calving were statistically significant affecting milk production of the random sample of dairy cattle herds in Dakahlia governorate in Egypt. The most probable Extra Internal Rate of Return (EIRR) was around 26, 31 and 33% for small, medium and large farm scale respectively. The highest negative effect on EIRR for the three farm scales is the increase of feeding costs; followed by the increase of number of services for conception ; lastly, the negative effect of the decrease of dairy cow milk price. Finally, to implementing and extend the successful applying of genetic improvement program in this governorate and the other governorates, this research recommends by the following:

- Training the inseminators to detect a precise heat on time and to a proper AI application for dairy cattle it would help in decreasing the number of services required for conception and shorts the service period, then the calving interval
- Providing health care and the proper feeding system for replacement heifers would enable them to reach the appropriate age for breeding; accordingly, they would reach a less age at first calving
- Availability of the livestock extension and computer expert systems and sufficient infrastructure of communication and transportation in the villages would be the basic elements of a successful genetic improvement program

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