



Munich Personal RePEc Archive

An Advance Study on Dairy Buffalo Development through Investment in Genetic Improvement

Soliman, Ibrahim and Bahgat, Basher

Zagazig University, Department of Agricultural Economics, Zagazig
University, Department of Agricultural Economics

April 2021

Online at <https://mpra.ub.uni-muenchen.de/109913/>
MPRA Paper No. 109913, posted 06 Sep 2022 19:34 UTC

**Research Aspects in Agriculture
and Veterinary Sciences
Vol. 1**



B P International

Research Aspects in Agriculture and Veterinary Sciences

Vol. 1

Research Aspects in Agriculture and Veterinary Sciences

Vol. 1

India ■ United Kingdom



B P International

An Advance Study on Dairy Buffalo Development through Investment in Genetic Improvement

Ibrahim Soliman^{1*} and Basher Bahgat²

DOI: 10.9734/bpi/raavs/v1/10147D

ABSTRACT

Dairy products are an important source of animal protein in Asian countries, especially for nutritionally vulnerable groups and vegetarians. As a result, the approach to increasing domestic milk supply is to increase buffalo milk yield through genetic improvement from the sperm of a selected buffalo sire with a high predicted milk difference. As a case study, data was collected from Artificial Insemination Centers in Egypt to use a dynamic mathematical investment model to estimate the rate of return (IRR) on genetic investment. Aside from the economic variables, the reproductive characteristics and feed efficiency are the most important variables in IRR. The anticipated most likely amount of IRR, 19.71%, was feasible. An increase of 10% in the number of conception services, age at First Calving, and service period would reduce the IRR by 7.51 percent. The IRR would drop by 9% if feed efficiency dropped by 10%. IRR would be reduced by 7% if feed costs, semen prices, and milk prices all fell by 10%. To import buffalo sires' semen of high predicted milk difference at moderate prices till establishment, domestic genetic merit is required.

Keywords: Dairy buffalo; feeds; genetic improving; investment model; reproductive traits.

1. INTRODUCTION

Egypt has a comparative advantage in producing milk from domestic dairy buffalo rather than red meat [1]. As a result, a feasible development plan is required to prioritize increasing domestic milk supply over red meat production from Egyptian buffalo, especially given the high cost of importing fresh milk and/or dairy products because they are perishable food commodities [2].

The importance of improving Egypt's domestic milk supply through genetic improvement arises from a shortage of resources for horizontal expansion in livestock population due to feed, water, and agricultural land resource constraints [3]. Dairy production in tropical regions has a lot of growth potential, but also poses a series of problems, particularly as dairy production systems were developed in temperate countries and in most cases are difficult to implement in the tropics [4-6]. 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 [7].

Egypt has almost no natural rangeland, which creates issues in high competition between grain crops and green foods on limited irrigation water and agricultural land to satisfy the demand for human food and livestock feed, respectively [8]. The main livestock feed is the Egyptian clover (Berseem), which is a winter season crop (Oct-May) that competes with wheat on agricultural resources [9]. Cultivated berseem area determines the milking head numbers, the calf crop, and the milk supply [10]. Therefore, the increase in dairy heads beyond the carrying capacity goes as offtake for slaughter [11].

Due to before mentioned constraints, expansion in livestock dairy heads would not be economical to cover the increasing deficit between milk production and the effective demand [11]. Accordingly, the only possible approach for livestock development in Egypt is to fix the livestock size within the

¹Department of Agricultural Economics, Faculty of Agriculture, Zagazig University, Egypt.

²Department of Agricultural Economics, Zagazig University, Zagazig, Egypt.

*Corresponding author: E-mail: ibsoliman@hotmail.com;

carrying capacity of the food availability allowance, focusing on the vertical expansion by increasing the milk yield per milking buffalo head [12], significantly. Such vertical expansion should be approached via genetic improvement of the domestic buffalo population using Artificial Insemination (AI) with the semen of selected buffalo sires [13]

The accumulation of costs and returns of genetic improvement over time and actualize the different strategies over different periods, should be expressed in comparable time units due to differential expression of improvement from a selection over time [14]. Discounting is the usual method of comparison for which revenue streams and future costs are transformed into existing values. Financial and economical are the two types of cost-benefit analysis [15]. The financial examination is the evaluation of a project's feasibility from the perception of agencies or individuals. The welfare of the nation at a core is considered for economic analysis. Financial analyses might be appropriate for Egypt as the breeding industry is often controlled privately [16].

In this regard, the study has designed and implemented a mathematical model to estimate the internal rate of return (IRR) along with the full productive life of the daughter of the dairy buffalo using the AI of the concerned sire's semen. The study estimated the most likely IRR at the average performance of the buffalo reproductive traits and the significant economic variables. After that, it estimated the impacts of unfavorable economic conditions, and less efficient reproductive traits, i.e., older age at first calving, more numbers of AI services required for conception, and a more extended service period leading to a longer calving interval, as well as the less feed efficiency.

To determine the return to investment of genetic improvement, the ordinary cash flow statement does not fit because livestock is a dynamic investment model of production, not an ordinary investment type. It is characterized by the depreciation of assets and treated via a systematic annual cash flow of benefits and costs. It needs a special financial mathematical model. The time horizon of such a model is determined by the inseminated dairy buffalo's production cycle and the five successive lactation seasons of its daughter. While the investment cost is determined by the semen dose price and the Number of conception services [17], the life cycle of such an investment is determined by the reproductive criteria.

The major reproductive criteria include age at first calving and the calving interval. As the gestation period is constant, the service period length determines the calving interval. On the other hand, the milk yield level and persistency period require adjustment for cow age and milking season order [18]. Feed efficiency is also an essential techno-economic variable that affects milk productivity and profitability as it represents the highest proportion of the operation costs of dairy cattle farms [19]. Most textbooks on feasibility studies of agricultural projects avoided such dynamic models [20-23]. Even the previous studies which applied assessment of the sire's predicted difference restricted the analysis for comparison among sires in terms of the net present value (NPV) of the first calving of the daughter because the authors were interested only in finding an index for sire's selection [24,25].

2. MATERIALS AND METHODS

The use of artificial insemination technology (AI) in Egyptian agriculture is very limited, whether with the traditional or specialized herds, and there is a lack of reproductive or even productive records in most farms [26]. Therefore, the study sample was restricted to the data of the records of the specialized research centers, where artificial insemination records can be obtained. Therefore, it is a purposive non-probabilistic sample.

As the number of artificial insemination centers is very limited in Egypt, the sample included the records of one of the largest Buffalo Research Stations in the Gharbia Governorate, which is in the middle of the Nile Delta region. It is managed by the Ministry of Agriculture and Land Reclamation.

Such a purposive sample provided various privileges. Firstly, the Centre's management understood the nature and importance of the study and thus, facilitated access to the required data. Secondly, the availability of records was for two herds at the station, one set was a flock of naturally inseminated dairy buffaloes with the semen of unselected bull (18 heads), and the second a herd of daughters of

buffalo dams artificially inseminated by the semen of selected buffalo sires (15 heads). The records of the first herd (18 heads) of dairy buffaloes were used to get the dairy buffalo's average productive and reproductive performance variables without genetic improvement. The second herd included the daughters (15 heads) of dams under the AI program of the improved sire's semen. The second herd records were used to get the average milk yield of the genetically improved daughters.

The average of productive and reproductive traits estimated from the records of the genetically unimproved sample is presented in Table 1. The milk yields over successive milk seasons of the genetically unimproved herd were used to calculate the Mature Equivalent Factor (MEF), as shown in Table 2. The MEF index was used to adjust the milk yield resulting from the estimated Predicted Milk Difference (PMD) to represent the improved milk yield of daughters over five successive seasons [27]. The second sample data were used to estimate the average milk yield per season of the daughters of the dairy buffalo dams inseminated artificially by the semen of selected buffalo sires raised in the artificial insemination center (Table 2). This sample was also used to estimate the PMD as the criteria of probable improvement in the milk yield of the Egyptian buffalo population in Egypt. When determining PMD, the population average of the daughters' milk yield was compared with the average milk yield of the genetically unimproved dairy buffalo herd.

The classical investment analysis model calculates the discounted net benefit derived from the cash flow as a stream of both annual inflows (costs) and outflows (benefits). However, it does not fit the purpose of the genetic investment analysis. The livestock investment model was affected by the changes in the reproductive cycle. Such a cycle comprises a set of variables that were measured in days and months and not on a full year base. These reproductive performance traits were mainly the age at the 1st calving, the service period (the period between calving and the successive conception of the dam), the calving interval (the sum of the gestation period and service period), and the Number of services required for conception and the mortality rate. Therefore, the IRR estimation (the discount rate that maximizes the return to investment) would be affected by nonsystematic periods measured in months. In addition, the outflows (revenues or benefits) are generated from the probable increase in milk yield of the daughters of the inseminated dam from the concerned breeding sire.

The sire is supposed to transfer what is called the "Predicted Selection Difference" of the milk of the semen, i.e., "PMD". It represents the potential quantity of milk, which is added to the average yield of his daughters. The investment costs in this study were the price of the units of AI from a certain sire's semen. The level of such a price was associated with the level of PMD. The feed costs were the bulk of the operating costs [28]. The feed cost was mainly a function of the feed conversion rate, which, in turn, was the most vital productive trait that affects the return to investment [29]. The incremental net benefit's model considered only the feed costs as the main variable costs' item, which directly affects the changes in milk yield.

2.1 The Model's Assumptions

- (1) The investment period expanded to 10 years, to allow for the genetic investment to give its full potentiality over five successive milking seasons of the daughter of the served dairy buffalo by the selected sire.
- (2) The average age at the first calving estimated from the field survey data.
- (3) As a conservative evaluation, it was assumed that the first replacement heifer of the offspring comes from the second calving of the served dairy buffalo.
- (4) To avoid the exact date of the conception, when the cost of the inseminated semen was allocated, it was assumed to be at the onset of each calving interval.
- (5) The gross margin above the feed costs introduced in the model was a ratio from the total income (incremental income above feed costs).
- (6) As the model focuses on genetic improvement of the milk yield, thereby the income generated from the calves' crop is neglected.
- (7) The minimum nominal interest rate was the financial average discount rate in the financial market of Egypt in 2017.
- (8) Such an interest rate was used as a standard to compare it with the rate of investment generated from the genetic improvement of the dairy buffalo. Therefore, the estimated IRR is

considered feasible if it passes the standard interest rate and is above the inflation rate in milk price.

- (9) The base period is the time of introducing the first semen service.
- (10) The discounted net present value should be calculated on a monthly base rather than a yearly basis.

2.2 Analytical Procedures

The analytical procedure was presented in a comprehensive approach via six sections: estimating PMD, the model's hypothesis, the model's equations, the definition of the model's variables, and the model's assumptions.

2.3 Estimation of the Predicted Milk Difference

The PMD was the probable increase in milk yield above the herd average transmitted from the semen of selected sire via the artificially inseminated dairy buffalo to its daughters. The PMD in this study was estimated from the model of Equation 1:

$$PMD = (MY_d - MY_h) * (h^2) \tag{1}$$

where:

PMD = Predicted Milk Difference supposed to be transmitted to the daughter via the inseminated dam from the selected buffalo sire,

MY_d = the average milk yield per daughter per season,

MY_h = the average milk yield per season of the target buffalo herd, and

h^2 = heritability coefficient of buffalo milk [30]

It should be mentioned that the mathematical model was presented in this study for assessing the feasibility of the AI program for genetic improvement of the milk yield of the domestic dairy buffalo. However, it was recommended for other dairy livestock-types (cattle, sheep, or goats) by introducing the correspondent technical coefficients of each type. In addition, it is valid not only for assessment of the genetic assessment of milk yield, but it is also applicable for other traits of milk quality, particularly milk fat and milk protein contents, which could be added to the model when such quality criteria have significant impacts on milk demand and price. If such traits were added, weights should be associated with each trait generated income to reflect the national strategy towards investment in genetic improvement for milk production.

2.4 The Mathematical Model's Equations

The model composed by the authors simulated the classical investment statement or the cash flow statement of the projects' appraisal [23], but it was adapted to fit the study's objectives. Therefore, it comprised of 17 equations, as follows:

$$NPV = nP_1 - nP_2(1+i)^{-a} - nP_3(1+i)^{-b} - I_1(1+i)^{-c} + I_2(1+i)^{-d} + I_3(1+i)^{-e} + I_4(1+i)^{-f} + I_5(1+i)^{-g} \tag{2}$$

$$I = r_c - r_p \tag{3}$$

Where:

r_c = interest rate in the Egyptian financial market

r_p = inflation rate of producer milk price

$$\Sigma NPV = Zero \sim i = IRR \quad (4)$$

Where:

NPV = Net present value

$$n = 100 / ACR \quad (5)$$

Where:

n = Average number of semen units/calving interval, for "k" intervals, where k = 1, 2, 3, 4, 5

$$ACR = CR(1 - \% \frac{MR}{100}) \quad (6)$$

Where:

ACR = Adjusted conception rate (%)

CR = Conception rate from the 1st service (%)

MR = Mortality rate of dairy buffalo (%)

$$I_k = M_k(I - R) \quad (7)$$

Where:

I_k = Incremental milk income above feed costs at calving interval k, in (EGP)

$$M_k = P_m \left(\frac{PMD}{MEF_k} \right) * (MD) \quad (8)$$

Where:

M_k = Incremental milk income at calving interval k, in (EGP).

PMD = predicted selection difference for daily milk yield (Kg) for the concerned breeding sire.

P_m = average price/ 1-kg of milk at the base year (EGP)

$$R = (M_k - FC) / M_k \quad (9)$$

Where:

M_k = Incremental milk income at calving interval k, in (EGP).

R = proportion of feed costs in gross milk income from a daughter of the breeding sire.

$$CI = GP + SP \quad (10)$$

Where:

SP = service period

GP = gestation period

$$a = AGC \quad (11)$$

$$b = a + CI \tag{12}$$

$$c = b + AGC + 0.5LP \tag{13}$$

$$d = c + CI \tag{14}$$

$$e = d + CI \tag{15}$$

$$f = c + CI \tag{16}$$

$$g = f + CI \tag{17}$$

where:

AGC = age at first calving

CI = calving interval

3. RESULTS AND DISCUSSION

The average reproductive performances of the domestic dairy buffalo were presented in Table 1. The average age at first calving was around 32.5 months; the service period was 135 days, and the calving interval reached 450 days. The required Number of services for conception was around 2.0. However, the effects of the order of lactation seasons of the dairy buffalo on milk production have been taken into consideration via correction for the MEM of dairy buffalo, as shown in Table 2. Accordingly, the PMD in the k lactation season was adjusted for the predicted milk yield per season over five successive seasons using the corresponding MEM index. The mature calving season is the 3rd season, where the PMD would reach its full performance, i.e., MEM equals one, and then there would be a slow decrease in the milk yield of the daughter in the 4th and the 5th season.

Table 1. Estimated averages of major traits of the inseminated dairy buffalo herd.

Productive and Reproductive Traits	Average
Average Number of Services for Conception	2.00
Average Adjusted Conception Rate from 1st service (%)	50%
Age at 1st calving (month)	32.50
Average daily milk yield (Kg)	7.6
Average lactation period per season (day)	230
Average Milk Yield per season (Kg)	1781.5
Average Carving Interval (Month)	450
Average Service period	135
Average feed costs per Kg milk (EGP)	3.15
Average Proportion of milk Cost in Total Revenue (%)	69%

*Source: Compiled and calculated per 1-dairy buffalo from the inseminated buffalo herd in the AI Center; except the last row, which comes from the records of the genetically improved daughters *EGP = (Egyptian pound); 1-US\$ = 17.60 EGP in 2017.*

Table 2. Estimation of the mature equivalent index of milk yield/ season (MEM)

Lactation Season	Mature Equivalent Factor
1st Lactation	1.4
2nd Lactation	1.2
3rd Lactation	1.
4th lactation	1.1
5th lactation	1.1
Average milk/season/ dairy dam (Kg)	1781.5

Source: Compiled and calculated from.

(1) Van Tassell, et al., 1995.

(2) The inseminated buffalo herd in the AI Center.

Therefore, the increase in the daughter milk yield would reach its full potential incremental increase (PMD =425 kg milk/day) as derived from Equation 1 in the 3rd season. Such an amount multiplied by the Number of milking days would be fully added to the average milk yield per cow of the herd, and a lesser amount of milk would be added to the other seasons.

3.1 Internal Rate of Return

IRR is the discount rate, which made the sum of the NPV equal to zero at the most probable levels of the performance profile. As shown in Table 3, IRR was estimated as 19.71%. It is much higher than both the annual inflation rate in milk price (10.5%), and the average discount rate in the financial market in 2017 was 16.0% [31] Therefore, the genetic improvement in domestic dairy buffalo was significantly feasible. The Number of domestic milking buffaloes in Egypt was around 1.769 million heads in 2015 [32]. Therefore, an expected additional increase in domestic milk supply per year due to genetic investment would be around 751,981 tons.

Table 3. Average economic and reproductive variables of the investment model

The Model's Variables	Symbols	Average
Economic Variables		
Farm Gate Price of Milk (EGP)	P _m	5.00
Average discount rate in the financial market in 2017 (%)	r _c	16%
Annual Inflation rate of producer Price of milk (%)	r _f	10.50%
Average Monthly discount rate (%)		1.33%
Semen Price per unit (EGP)	P _s	50
Proportion of milk Cost in Total Revenue (%)	R	69%
Technical Variables		
Expected Selection Difference of the semen (Kg)*	PDM	425.00
Average Number of services for conception	ACR	2.00
Adjusted Conception rate from 1st Service (%)	CR	50.00%
Mortality rate of Dairy Cows	MR	1.2%
Age at the First Calving	AGC	32.5
Calving Interval	CI	450
Service Period	SP	135

Such an incremental quantity would reach around 13.5% of the existing milk production of Egypt, which reached 5.551 million tons in the same year. However, such a predicted increase in milk production covers around 64.4% of imported fresh dairy products, estimated as milk equivalent [32]. If buffalo milk were estimated as 4% fat milk equivalent, rather than 7.8%, using Jean's equation [33], the expected increase in milk yield would represent about 23% of total milk production and 109% of imported milk equivalent of dairy products.

3.2 Sensitivity Analysis of the IRR towards Undesirable Conditions

The predicted changes in the IRR due to probable deterioration in reproductive and productive performances of the domestic buffalo were estimated as presented in Table 4. A 10% increase in the Number of services for conception, age at first calving and service period would aggregately decrease the IRR by 7.5% to be around 12.2%, i.e., the IRR on the genetic investment would not be feasible as it became less than the interest rate on livestock loans. An increase in feed costs by 10% would drop the IRR by 9% to reach about 11%, which almost covers the annual inflation in milk prices, without any positive net benefit to entrepreneurs. Such an increase in feed costs could be due to either an increase in feed prices or a decrease in feed efficiency.

Table 4. Estimation of most probable IRR and sensitivity analysis

Model's Critical Variables	Expected Change	Estimated IRR	Change in IRR
Most Probable IRR	No change	19.71%	0.00%
Milk Price	10% less	15.98%	-3.73%
Semen Unit Price	10% more	16.67%	-3.05%
All Economic Variables		12.67%	-6.98%
Number of services for Conception	10% more	16.26%	-3.38%
Age at the First Calving	10% more	16.15%	-3.50%
Service Period	10% more	19.09%	-0.62%
All Reproductive Traits	10% more	10.85%	7.50%
Feed Efficiency	10% more	14.06%	-5.65%

Source: Calculated from the Investment Model using Tables 1 and 2

Unfavorable changes in the economic variables, i.e., a 10% increase in semen dose price and milk price, would be around 7%. It is of less drastic negative impact on IRR than a similar change in reproductive traits or feeds efficiency, i.e., to reach around 13%.

Therefore, a national research work supported by an effective extension program should be implemented to improve the reproductive traits and feed efficiency of the buffalo population.

3.3 Policy Implications

A 10% increase in the feed conversion rate decreases the return to investment of the genetic improvement of dairy buffalo by 9%. A 10% increase in the Number of services for conception, service period and age at first calving would also decrease such a return to investment by another 7.5%. Therefore, to assure a feasible return to investment in such a program, some supporting policies are required.

Among those policies is a training program for the inseminators and dairy buffalo holders on precise heat detection on time and proper application of AI. Such a program would help in decreasing the Number of services required for conception and consequently, the calving interval, which raises the return to investment. A supporting program should be associated with it. Such program objectives are a sufficient communication system for calling the inseminators on time, and the availability of sufficient transportation means in the villages, such as motorcycles.

A proper feeding system for replacement heifers would enable them to reach an appropriate weight earlier for breeding at a younger age for first calving. A credit line of soft loans should be provided to veterinary and agriculture college graduates to establish AI stations, and large investors to establish AI centers that produce liquid nitrogen and prepare the semen dose containers.

4. CONCLUSION

The main method of genetic improvement of buffaloes in Egypt was the importation of buffalo sire's semen. These were the tactics of choice due to the inadequate development of local breeding

infrastructure. However, local progeny might be an economically suitable option for Egypt and can be an effective alternative with restricted foreign currency. Therefore, an economic assessment of a series of alternatives is required with a range of strategies and methods that might be beneficial to develop effective breeding policies for buffaloes, not only in Egypt but also in Asian countries.

The dairy breeding industry will consequently benefit from the major investment in genetic improvement research that is presently underway.

Genetic improvement programs would be embraced by large dairy producers and will consequently provide a sound investment market. The unemployment would be reduced due to the consolidation of the artificial insemination network and other dairy industries, where, currently, the investments in the dairy sector Egypt, by private and public institutions are inappropriate.

A national program for artificial insemination should be established in Egypt via building up a network of AI centers that would serve AI units in the villages according to the buffalo population size by geographic distribution all over the country.

ACKNOWLEDGEMENT

The authors are very thankful to all the associated personnel in any reference that contributed to/for this research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Soliman I. Role of dairy buffalo in Egypt food security, Buffalo Newsletter, Bulletin of The FAO Inter-Regional Cooperative Research Network on Buffalo and of the International Buffalo Federation 2008;23.
2. Soliman I, Bassiony H. Egyptian agricultural exports competitiveness L'Egpte contemporaine, Société Egyptienne d'Economie Politique de Statistique et de Législation. 2012;(505):210-229.
3. El Mowafy AE. Techno-Economics Assessment of Genetic Improvement via Artificial Insemination in Dairy Cattle in Dakahlia Governorate. Trends in Agricultural Economics. 2015; 8(21):21-27.
Available: <https://doi.org/10.3923/tae.2015.21.27>
4. Hernández-Castellano, Lorenzo E, et al. Dairy science, and health in the tropics: Challenges and opportunities for the next decades. 2019;1009-1017.
5. Habib MR, Haque MN, Rahman A, Aftab uzzaman M, Ali MM, Shahjahan M. Dairy buffalo production scenario in Bangladesh: A review. Asian Journal of Medical and Biological Research. 2017;3(3):305-16.
6. Borghese A, Mazizi M. Buffalo population and strategies in the world. Buffalo Production and Research. 2005;67:1-39.
7. Soliman, Ibrahim, Ahmed Mashhour. Techno-economic factors affecting genetic investment in dairy cattle in Egypt. 2014;156-161.
8. Safwat M, Soliman I, Amer J, Fouad S. The Impacts of Economic Reform Policies on Wheat and Egyptian Clover. Zagazig Journal of Agricultural Research. 2015;42:397-404.
9. Abo El Goud SA, Mersal IF, Haggag MEM. Effect of potassium fertilizer rates and some plant extracts on forage, seed yield, and seed quality of Egyptian berseem under saline soil conditions. Journal of Plant Production. 2015;6:1183-1198.
Available: <https://doi.org/10.21608/jpp.2015.51222>
10. Radwan MAA. Characterization of milk and veal production chains of buffalo under crop-livestock production system in Egypt, Doctoral dissertation, Faculty of Agriculture, Cairo University; 2016.

11. Soliman I. Role of dairy buffalo in Egypt food security, Buffalo Newsletter, Bulletin of The FAO Inter-Regional Cooperative Research Network on Buffalo and of the International Buffalo Federation. 2008;23.
12. Soliman I. Economic feed utilization for dairy buffalo under the intensive agricultural system. Italian Journal of Animal Science. 2007;6:1367-1375.
Available: <https://doi.org/10.4081/ijas.2007.s2.1367>
13. Warriach HM, McGill DM, Bush RD, Wynn PC, Chohan KR. A review of recent developments in buffalo reproduction—a review. Asian-Australasian Journal of Animal Sciences. 2015;28:451-460.
Available: <https://doi.org/10.5713/ajas.14.0259>
14. De Vries A. Economic trade-offs between genetic improvement and longevity in dairy cattle. Journal of Dairy Science. 2017;100:4184-4192.
Available: <https://doi.org/10.3168/jds.2016-11847>
15. Kadam Ideen HN, Manzoni G, Watanabe YF, Strøbech L, Baruselli PS, Meirelles FV, Nogueira MFG. Genomic selection of in vitro produced and somatic cell nuclear transfer embryos for rapid genetic improvement in cattle production. Animal Reproduction (AR). 2018;12:389-396.
16. Pangmao S, Thomson PC, Khatkar MS. Dairy cattle industry and genetic improvement programs in Thailand. Animal Production Science. 2017;57:1242-1247.
Available: <https://doi.org/10.1071/AN16454>
17. Soliman I. The economic feasibility of artificial insemination methods in genetic investment programs. In Proceedings of the Seminar on Artificial Insemination Projects Planning in The Arab Countries (AIPPAC'85), The Kingdom of Morocco, Rabat. 1985;1-29.
18. Mashhour AFMF. Economics of Biotechnology for Dairy Cattle in Egyptian Agriculture: Genetic Investment, Doctoral Dissertation, Dept. Agri. Econ, Faculty of Agriculture, Zagazig University, Egypt; 1995.
19. Soliman I, Sadek MH. Impacts of Productive and Reproductive Performances on Investment Efficiency of Buffalo Enterprise in Egypt, proceedings of 7th World Buffalo Congress. International Buffalo Federation: 212-217, Manila, Philippine; 2004.
20. Uwe G, Daryl N, Peter S. Investment Appraisal: Methods and Models. 2ed. Springer Texts in Business and Economics, Switzerland; 2015.
21. Barnard CS, Nix JS. Farm Planning and Control. Cambridge University Press, Cambridge. UK; 1979.
Available: <https://doi.org/10.1017/CBO9780511559914>
22. Brown, Maxwell L, Farm Budgets: From Farm Income Analysis to Agricultural Project Analysis, The Johns Hopkins University Press, Baltimore; 1979.
23. Gittenger JP. Economic analysis of Agricultural Projects. 2nd Ed. John Hopkins University Press. Maryland, USA; 1982.
24. Blake RW, Shumway CR, Tomaszewski MA, Rickard GP, La Bore JM. Profit-maximizing dairy sire selection package. Journal of Agricultural and Applied Economics. 1988;20:141-144.
Available: <https://doi.org/10.1017/S0081305200025723>
25. McMahan RT, Blake RW, Shumway CR, Leatham DJ, Tomaszewski MA, Butcher KR. Effects of planning horizon and conception rate on profit-maximizing selection of artificial insemination sires. Journal of Dairy Science. 1985;68:2295-2302.
Available: [https://doi.org/10.3168/jds.S0022-0302\(85\)81102-4](https://doi.org/10.3168/jds.S0022-0302(85)81102-4)
26. Ibrahim M. A. R. Water buffalo for our next generation in Egypt and in the world. Scientific Papers. Anim. Sci. 2012;55:183-192.
27. Van Tassell CP, Jones LR, Elicker SW. Production Evaluation Techniques Based on Lactation Curves. Journal of Dairy Science. 1995;78(2).
Available: [https://doi.org/10.3168/jds.S0022-0302\(95\)76655-3](https://doi.org/10.3168/jds.S0022-0302(95)76655-3)
28. Pryce JE, Coffey MP, Simms G. The relationship between body condition score and reproductive performance. Journal of Dairy Science. 2001;84:1508-1515.
Available: [https://doi.org/10.3168/jds.S0022-0302\(01\)70184-1](https://doi.org/10.3168/jds.S0022-0302(01)70184-1)
29. Soliman I. Buffalo Share in Small Farmer Welfare Under Intensive Agricultural System: The Case Study of Egypt. Proceeding of 10th World Buffalo Congress & 7th Asian Buffalo Congress, 6-8 of May, Invited Papers, Phuket Thailand. 2013;1:132-140.

30. Negm AA, Abdel-Salam SAM, El-Sayed M, Sadek RR, Abdel Aziz AS. Preliminary results on use of the open nucleus breeding scheme for improving milk production of Egyptian buffalo. *Egypt J. Anim. Prod.* 2005;42:1-9.
Available: <https://doi.org/10.21608/ejap.2005.92904>
31. CAPMAS, Central Agency of Public Mobilization and Statistics. *Monthly Bulletin of Food Prices in Egypt*, Nasr City, Cairo, Egypt; 2017.
32. FAOSTAT: FAO Statistics Division, FAOSTAT <fao.org>2017.
33. Soliman I, Abdul Zaher T. The Impact of Government Policies on Efficiency of Milk Production Systems in Egypt Proceedings Of 9th International Congress of Statistics, Computer Sciences, Social and Demographic Research, P. 1-21, Scientific Computer Center, Ain Shams University, Cairo, Egypt; 1984.

Biography of author(s)

Prof. Ibrahim Soliman

Department of Agricultural Economics, Faculty of Agriculture, Zagazig University, Egypt.

He is a professor of agricultural Economics at Dept. Agri. Econ., Zagazig University (ZU) in Egypt and the Chairman of the permanent committee for promotion of the Assist. and Assoc. Prof. in Social and Economic Agricultural Sciences. He was the former chairman of the Dept. Ag. Econ., ZU, associate research professor at American University in Cairo, an economic consultant of Kuwait Livestock and Transportation Company, research scientist at Kuwait Institute for Scientific Research; the economic consultant of the Egyptian ministry of trade and supply. He got his B. Sc. in animal science from Ain Shams University in Cairo. He acquired M.Sc. in animal physiology, M.Sc. in agricultural economics. He completed his PhD program Jointly in Iowa State University and Ain shams university. He is a scientific fellow with the Egyptian Academy of Scientific Research and Technology, a member of the national specialized councils of the Egyptian presidency. and the supreme council of culture in Egypt. He is an international economic consultant for FAO, AOAD, USAID, EU and Care Int. He was the Principal Investigator of 27 research projects on agricultural and rural development in Middle East and African countries. He was a visitor research professor at several universities in USA, GB, Germany, China, and Zimbabwe. He published 270 research papers of which 125 were at international conferences and in peer reviewed international journals. He was a coauthor of 4 International Books on sustainable agriculture development and food Security and the author of 7 books in Arabic on Econometrics, Agricultural Development systems and Natural Resource Economics and Marketing Systems. He acquired the State prize of Agriculture from Egyptian Academy of Science, the 1st class Medal from Egypt's president, the prize of appreciation and the prize of Scientific Excellency in agriculture sciences from Zagazig University, the university shield at the Silver Jubilee ceremony and numerous certificates of appreciation from several international scientific associations.



Dr. Basher Bahgat

Department of Agricultural Economics, Zagazig University, Zagazig, Egypt.

He is an Assistant Researcher in the Department of Project Management and Sustainable Development, City of Scientific Research and Technological Applications, Borg Al Arab, Marca Matrouh providence, Egypt. He completed his B. Sc. "Agricultural Sciences" -Faculty of Agriculture, Ain Shams University, Egypt, M. Sc., Agricultural Economics, Faculty of Agriculture, Zagazig University, Egypt, 2012, Ph.D. in Agricultural Economics, Faculty of Agriculture, Zagazig University, Egypt, 2018. He has Publication of 5 research Articles in the field of Livestock Development. He served as an Engineer of the Egyptian Real Estate Company for Land Reclamation (2007-2015), Research Assistant, Department of Agricultural Economics, Faculty of Agriculture, Zagazig University from 2015.

© Copyright (2021): Author(s). The licensee is the publisher (B P International).

DISCLAIMER

This chapter is an extended version of the article published by the same author(s) in the following journal. Journal of Buffalo Science, 9: 181-188, 2020.