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ABSTRACT: The national strategies for the irrigated intensive agricultural system in developing countries should focus upon Producing less expensive milk from dairy buffaloes that, efficiently, utilize the limited expensive produced feed resources. Therefore, planning for the least cost feeds combination is the most recommended approach to keep buffalo milk price at a competitive level and being low enough to make milk available for the major proportion of the low-income households, particularly "Vulnerable Groups". Estimation of the least cost feed ration combination of the limited expensive feed resources were conducted from a recent farm survey of the dairy buffalo performances and the feed use pattern in Egypt. The estimated average production elasticity of fodder, concentrate feeds mix and straw, implies that their shares in generated buffalo milk income are 41.7%, 35%, and 23.3%, respectively.. The response of the human labor was of negative direction and statistically insignificant. This means that the labor used per dairy buffalo was beyond the economic level, that reflects the excess farm-family labor involved in such activity, because they have almost nil opportunity income of off farm work. The other capital inputs have small positive effect on milk production, The average marginal return from milk per one-dollar expenditure reached $.1.08 for fodder, and $ 1.04 for concentrated feed mix, i.e. it is feasible to expand the usage of fodder more than concentrates. The wheat straw has shown uneconomic efficiency. Therefore, it is recommended to limit its level in the ration. The least cost ration reduces feed cost of one ton of buffalo milk equivalent (4% fat) by 22%. The less costs of production will strength the competition of domestic supply either against in the international export market or against the dumping policies followed by exporters to the domestic market.

Key words: Economic feed, Water buffalo, Intensive system.

INTRODUCTION - Water buffalo is a main dairy animal under the intensive irrigated agriculture system in many developing countries. Egypt is a typical case study of such system. This system faces the problem of competition between grains and fodder crops on limited land and water resources and between human and animal on available grains. Under irrigated intensive agricultural system in developing countries, milk production has a comparative advantage in agricultural resource use, in terms of net cots per 100 grams animal protein (Soliman and Zaher, 1984; Soliman, 1985a).Estimates of the Economic Criteria have ranked milk production from buffaloes at the top of other livestock systems raised on intensive farming systems (Soliman, 1991; Soliman and Mashour, 2002; Soliman and

Sadek, 2004). The common Agricultural pattern under Irrigated agriculture in most of the developing countries is characterized by small farm holdings, with few numbers of milking animals. However, livestock activities, particularly buffalo holdings, provide a feasible opportunity income for the abundant family-labor on farm of the household members. Socio-economic studies have provide evidences that the opportunity income from off farm work of such excess farm-family members is, often, much less than what he (she) can get from raising dairy buffalo on farm. Rural women have the highest share among other household members in labor work for buffalo holdings on traditional farms (Soliman and Ragab, 1985; Soliman, 2004). In addition, milk is one of the most vital recommended food item to compensate the nutrition deficit among the high proportion of the male nourished "Vulnerable groups" in the developing countries communities (Soliman and Shapouri, 1984; El Asfahani and Soliman, 1989; Soliman and Eid, 1992; Soliman and Eid, 1995). Therefore, the national strategies for the irrigated intensive agricultural system in developing countries should focus upon Producing less expensive milk from dairy buffaloes that, efficiently, utilize the limited expensive produced feed resources. Accordingly, the objective of this study is to evaluate the economic efficiency of feed response of dairy buffalo under the intensive irrigated agriculture system. Achievement of this objective requires estimation of the least cost feed ration combination of the limited expensive feed resources. The suitable model to reach that is to estimate the best fitted form function of the feed-milk response for dairy buffaloes. The case study is from a recent farm survey on the dairy buffalo performances and the feed use pattern that has been conducted in Egypt.

MATERIAL AND METHODS - The study use the input-output field data from a recent farm sample survey conducted in Egypt in 2005, which cover the agricultural year (2004/2005). The sample forms were applied on farms from four villages in mid and eastern Nile-delta. The Nile-Delta represents the bulk of the agricultural acreage of Egypt. The sample size was 50 farms. They were drawn as a stratified random sampling technique. Therefore, the sampled farms represented the available farm size classes, i.e. (less than one Feddan, 1 to less than 3 feddan, 3 to less than 5 feddan, 5 to 10 feddans, 10 feddans and more). One feddan =4200 m^2. Each class included 10 farms. The survey forms were filled through two field visits for the same farms. The first was by the end of the agricultural winter season (by the end of May). The second visit was by the end of the agricultural summer season (by the end of August). The collected cross section data were used to estimate a dairy buffalo production function represented by (Equation 1)

Equation 1: $M = f(C, G, S, L, K)$

Where:

M = Milk yield quantity per dairy buffalo per lactating season in kilograms,

C = Concentrate feed mix quantity fed to one dairy buffalo per year in kilograms,

G = Green fodder quantity fed to one dairy buffalo per year in kilograms,

S = Straw quantity fed to one dairy buffalo per year in kilograms,

L = Human labor used for serving one dairy buffalo per year in working hours,

K = an aggregate variable in $ expresses Other Capital inputs used for one dairy buffalo per year.

Although feed inputs are capital inputs they were introduced as separate explanatory va-

riables, because the feed responses represent the main target variables behind the estimation of the buffalo production function in this study. The concentrate feed mix is a common concentrate feed used in Egypt. Its nutritive value is about 55% starch equivalent, 18% crude protein. It composes of yellow corn; cotton seed cake, wheat and rice bran, all are mixed with sugar cane molasses. It is processed in private feed processing plants and traded as pellets. The common green fodder in Egyptian agriculture is "Berseem"(Egyptian Clover). It is a seasonal winter cultivated crop, competing mainly with wheat for land and water use. The nutritive value of fresh green "Berseem" is 8% S.E. and 2% crude protein. Wheat straw is the main dry roughage feed provided for livestock. The straw nutritive value is around 23% S.E. and almost nil of crude protein. Human labor hours used for cleaning, feeding, watering and milking were aggregated and averaged per milking buffalo head.
The best-fitted form of the concerned production function was selected on base of the economic concept, statistical inferences of the estimated regression coefficients and the estimated adjusted coefficient of determination (R^{-2}) (Soliman, 1985b; Soliman and El Zanati; 1987; Soliman 1992). The literatures have shown that "Cobb-Douglas" was the best-fitted estimated functions for the field cross section data of input output relations. It is a power function (Equation 2)

Equation 2: $M = aC^{b_1} G^{b_2} S^{b_3} L^{b_4} K^{b_5}$

Estimates of (a) and b(s) are the estimated response parameters. While (a) shows the level of technology, the regression coefficients [b(s)] show the milk response magnitude and direction of each corresponding input. The regression coefficients express also the production elasticity of each input. The production elasticity of a given input, estimates the relative change in milk production per buffalo head per year resulting from an increase of 1% in the quantity used from this input. On the other hand, the economic efficiency of inputs are estimated using

Equation 3: $(\text{Economic Efficiency})_x = (VMP)_x / (\text{Price of the input}) = P_m (MP)_x / P_x$

Where:

$(VMP)_x$ = Value of Marginal Product of input x

(P_m) = Price of milk

$(MP)_x$ = Marginal product of input X = $(\Delta M)/(\Delta X)$ = change in milk production due to an increase in input x by one unit.

The "Isoquant Curves function" (Equation 4) was derived from the production function (Equation 2). The isoquant curve shows all-possible combination of two inputs quantities (two feed ingredients) that can be fed to produce a given level of output (milk yield). The marginal rate of technical substitution of the two inputs ($MRTS_{x1,x2}$) was estimated from the isoquant curve function. The least cost ration combination of both concentrate-feed mix and green fodder was estimated, assuming all other inputs were at their average levels. The necessary condition to achieve the least cost combination of both feed inputs is recognized when the ($MRTS_{x1,x2}$) equates a given price ratio of the two feed inputs, (Equation 5). From (Equation 5) it is possible to drive the Isoclines function" which determine the substitution relationship between both feeds at different price ratio (K) of both feed ingredients.

Equation 4: $C = (M^*/aG^{b_2})^{1/b_1}$

Equation 5: $\Delta C/\Delta G = b_1/b_2\,(G/C) = P_g/P_c$

Equation 6: $C\,(^{/}\, b_1/b_2)\,K = G$

Where:
M^* = a given level of milk yield per dairy buffalo,
P_g and P_c = the price per kilogram of green fodder and concentrate feed mix, respectively,
K = the price ratio of concerned feed inputs (fodder and concentrate-feed),
Other symbols represent the same variables of (Equation 1, Equation 2).

RESULTS AND CONCLUSIONS - Dairy Buffalo Performances at the National Level. Although milk production in Egypt increased from about 3,777 thousand tons in the year 2000 to more than 4,100 thousand tons in the year 2005, the self-sufficiency in milk decreased from 85% to 82%, (Table 1). Although imports of milk increased from 663 thousand tons in the year 2000 to about 1,024 thousand tons in the year 2005, milk exports showed huge increase along the same period, i.e. from 16 thousand tons to more 125 thousand tons (Table 1). Rapid expansion in dairy products export implied that the domestic milk products had a considerable market abroad. The producer price per ton of milk reached about 40% of the same price in Italy, (Table 2). This indicator showed that Egypt has a comparative and competitive market in exporting milk products. The annual per capita consumption of milk in Egypt was around 57 kilograms in the year.

Table 1. Average Performances on National Level of Dairy Buffalo in Egypt.

Item	2000	2001	2002	2003	2004	2005
Total Milk Production, (000) Tons	3,777	3,939	4,192,450	5,255	4,501	4,103
Production of Buffalo milk (000) Tons	2,03	2,213	2,087	2,55	2,267	2,3
% Buffalo milk in Total milk production	54%	56%	50%	49%	50%	56%
Total Milk Production as milk equivalent 4% fat (000) Tons	5,198	5,488	5,653	7,04	6,087	5,713
Production of Buffalo milk, Equivalent 4% fat, (000) Tons	3,452	3,762	3,548	4,334	3,854	3,91
% Buffalo milk in Total milk production as Equivalent 4% fat	66%	69%	63%	62%	63%	68%
Stock of Buffaloes (000) Heads	3,379	3,532	3,55	3,777	3,845	3,92
Buffalo in milk (000) Heads	1,515.15	1,64	1,64	1,59	1,619	1,64
% Buffalo in milk of Total Stock	45%	46%	46%	42%	42%	42%
Milk Yield per Buffalo Per Year (Kg)	1,34	1,349	1,273	1,603	1,4	1,402
Producer price (US $/ton) of All Milk	390.1	365.6	329.6	288.2	NA	NA
Producer price (US $/ton) of Buffalo Milk	432.0	402.7	368.9	316.2	NA	NA
Milk Consumption/Kg/capita/Year, Milk	55	57.2	59.3	60.6	59.1	56.7
% of self-sufficiency of milk	85%	87%	87%	89%	91%	82%
Quantity Imported of Milk (000) Tons	663	616	667	684	503	1,024
Quantity Exported of Milk (000) Tons	16	17	29	59	58	125

Source: Estimated from: Food and Agricultural Organization of he United Nations (2007). "Internet Site" (www.fao.org), Data Bas Statistics, FAOSTAT.

Table 2. Average Performances on National Level of Dairy Buffalo in Italy.

Item	2000	2001	2002	2003	2004	2005
Stock of Buffaloes (000) Heads	182	194	185	222	210	205
Buffalo in milk (000) Heads	124	161	161	166	154	137
% Buffalo in milk of Total Stock	68%	83%	87%	75%	73%	67%
Milk Yield per Buffalo Per Year (Kg)	1090	955	915	1035	1194	1379
Producer price (US $/ton)of Buffalo Milk	586.5	591.54	627.73	644.45	NA	NA
Milk Consumption/Kg/capita/Year	237	234.1	227.7	220.8	214.4	208.8

Source: Estimated from: Food and Agricultural Organization of he United Nations, (2007). "Internet Site" (www.fao.org), Data Bas Statistics, FAOSTAT.

This was far from such level in developed countries, (e.g. the annual per capita milk consumption in Italy reached around 209 kilogram in 2005). This is an additional incentive to expand domestic production of milk. However, any feasible plan to expand milk production should depend mainly on development of dairy buffalo production, This is because its share is more than one-half of the domestic production on natural milk basis. Even though, such share reaches two-thirds if milk production on base of 4% fat adjusted milk, (Table 1). Producer's price of buffalo milk in Egypt was 10% higher than the national average of milk price due to its richer demanded quality than cow's milk. Even though the Egyptian producer price of "buffalo milk was much less than that price in a developed country like Italy, (Table 2). Not only that but the average milk yield of the Egyptian Buffalo has also increased over the last decade to reach about 1400 kilograms per buffalo head in 2005 (Table 1), which surpassed the average yield of the Italian buffalo, (Table 2).

Therefore, the analysis of the national aggregate data provided several evidences that buffalo milk development is a promising feasible strategy; under irrigated intensive farming system, as the case study of Egypt. However, such strategy approaches its fruits, if and only if, the national planning focuses upon keeping the costs of production at minimum, to keep buffalo milk price at a competitive level and being low enough to make milk available for the major proportion of the low-income households, particularly "Vulnerable Groups". This is because feed costs represent the main proportion of the milk costs of production. Besides, feed prices are high under intensive irrigated agriculture system 0. Such strategy would share, significantly, in fulfillment of the three conditions of the food security *"Availability, Adequacy and Accessibility"* {The 3 A's conditions of food security} (Soliman and Shapouri, 1984; El Asfahani and Soliman, 1989; Soliman and Eid, 1995).

The dairy buffalo production function was estimated using the cross section data of the field sample survey (50 farms with 143 heads of dairy buffaloes). The target function was as shown in (Equation 7), where the values within parentheses under the estimated response parameters are the estimated standard errors of the corresponding estimates.

Equation 7: $M = 7.049C^{0.271}G^{0.323}S^{0.180}L^{-0.024}K^{0.008}$

(0.394) (0.271) (0.102) (0.061) (0.063) (0.01)

Estimated F ratio = 952.23 and the estimated $R^{-2} = 0.97$.

The results showed that the estimated model fitted the input-output response at very high level of significance due to the high value of F-ratio. Also the estimated adjusted coefficient of determination (R^{-2}) showed that about 97% of the variation in milk yield per season of a dairy buffalo was due to the changes in concerned inputs (Feeds, labor and other Capital inputs). The estimated average annual milk yield per dairy buffalo from the sample survey was 3221 Kg (4% fat equivalent).
The estimates showed significant response to changes in green fodder, concentrated feed mix and roughage (straw). As aggregate response a 10% increase in total feed inputs increase the buffalo milk yield by about 7.7% This result implies that feeds availability provides a promising opportunity to expand the buffalo milk supply. However, such decreasing return to scale implies that an additional 1-Kg of milk would be at higher cost than the preceding one, (Equation 7). This is another evidence showing the importance of determining the least cost feeds combination.
The estimated average production elasticity of fodder, concentrate feeds mix and straw, implies that their shares in generated buffalo milk income are 41.7%, 35%, and 23.3%, respectively. The highest share of "Berseem" (Egyptian Clover) in income generation from buffalo milk provides evidence why the Egyptian farmer prefers to expand "clover" area at the expenses of wheat acreage. Therefore, the government has raised in recent years a grantee farm price policy of wheat, even above the international level, to provide incentives for the farmers to increase wheat area at a significant rate over the last decade.
The average marginal product per additional kilogram of feed as milk equivalent 4% fat was 0.195 kilogram for green fodder and about. 1.295 kilogram for additional 1-Kg of concentrated feed mix and around 0.04 kilogram for additional 1-Kg of straw. This means that the estimated average ration content including maintenance are about 0.85 Kilogram of starch equivalent per additional 1-Kg (milk equivalent 4% fat), of which 59% fodder, 39%Concentrates, 1% rough. However, the curvilinear nature of the estimated function showed that the feed conversion rate is not constant. The higher the milk yield the more is the feeds required per additional kilogram of milk. This reflects the due to the diminishing rate of return to feeds.
From (Equation 7) the response of the human labor was of negative direction and statistically insignificant. This means that the labor used per dairy buffalo was beyond the economic level. This is mainly due to the excess farm-family labor involved in such activity, because they have almost nil off farm opportunity income, 0. The aggregated monetary variable that expresses the other capital inputs has statistically small positive response on milk production, indicating that 10% increase in expenses other than feeds raise the milk production by 0.4%, (Equation 7). The bulk of such expenses are the veterinary care
The Economic Efficiency of Feed Utilization for Buffalo Milk. The Economic efficiency of feed inputs was estimated as the average marginal return from milk per one-dollar expenditure on each feed. It reached $1.08 for fodder, and $1.04 for concentrated feed mix, (Table 3), i.e. it is feasible to expand the usage of fodder more than concentrates within the allowance boundaries of the milk-feed response. The wheat straw has shown uneconomic efficiency, because the marginal return was less than one dollar for each dollar spent on wheat straw, (Table 3). Therefore, it is recommended to limit the level of straw in the ration.
It should be mentioned that the survey data showed that the producer's price of buffalo milk reached $ 269.57 per ton, in 2005, (Table 3) which was less than its level in 2003, i.e. $ 316.2 per ton. This implies that buffalo milk production in Egypt, even under irrigated feed production, moves towards more competitive and comparative advantage in resources use.

Table 3. Estimates of the Marginal Return per one Dollar Expenditure on Feeds.

Variable	Estimate
Buffalo Milk Price Per Ton ($)	269.57
Clover Price Per Ton ($)	14.96
Concentrate price per ton ($)	222.78
Wheat Straw Price Per Ton ($)	9.04
Return to one Dollar expenditure on one Ton Feed:	
Fodder (Egyptian Clover)	1.08
Concentrate Feed Mix	1.06
Wheat Straw	0.89

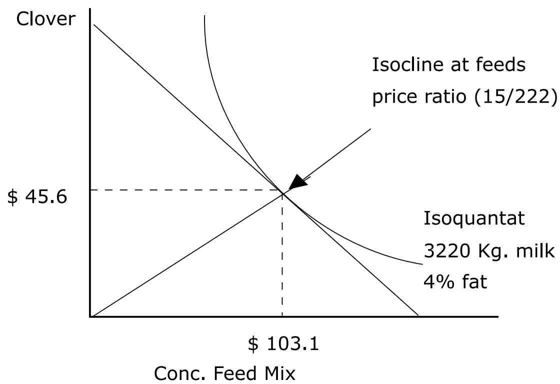
Source: Estimated from:
(1)The production function estimates (Equation 7).
(2) The sample survey cross section data of the study.

The isoquant curves function is derived from (Equation 7) at the market price ratio of the fodder (Egyptian clover) and (Concentrate feed mix) used for feeding dairy buffalo in 2005 as shown by (Equation 8)

Equation 8: $X_{1i} = \left[\frac{3000}{7.049\,X_{2i}^{\text{[illegible]}}}\right]^{\text{[illegible]}}$

Estimation of the least cost ration using Equation 8 as well as Equation 5, Equation 6 is shown in Figure 1and Table 4. The presented results indicated that it is possible to reduce feed costs of one ton of buffalo milk equivalent (4% fat) by 22%, i.e. from the existing level of $192, to about $148.70. This will be reflected in less milk price in the market without causing losses in farmers' income. Therefore, the competitive opportunity of domestic supply will increase. The less costs of production will strength the competition of domestic supply either against competitors' price in the international export market or against the dumping policies followed by EEC or USA for keeping their exported dairy commodity prices to Egypt at much less than their economic levels.

Figure 1. Isoquant Curve, Isocline's Curve and Least Cost Ration.



Source: Drawn from: (1) Equation (Equation 8) (2) Prices shown in (Table 3)

On the other hand, the least cost ration implies to save a significant proportion of buffalo feed expenditure on national level by about 169.29 million dollars. Physically, it saves 122,016 tons of feed concentrate mix, which are provided to the dairy buffalo herds, i.e. saving about 113,263 million dollars of imported maize. However, the least cost ration requires increasing the clover proportion in the ration by 120 thousand acres. Such expected expansion in clover area will be at the expenses of wheat area leading to an increase in imported wheat bill by 26 million (2005 prices). Therefore, economic allocation of feed resources showed a high feasible enterprise of dairy buffalo under intensive irrigated agricultural system, condition that the least cost ration policy is applied.

Table. 4. The least Cost Ration and The Expected Saving in Buffalo Milk Costs.

Item	Estimate
Average Annual Milk Yield/ Dairy Buffalo (4% Fat) in Kg.	3221.4
National Buffalo Milk Production in Tons	3,910,000
Aver Price Per Ton of Fodder ($)	14.96
Aver Price Per Ton of Concentrate Feed Mix ($)	222.78
Actual Feed Consumption per Ton of Milk Produced (Kg):	
Fodder (Egyptian Clover)	2501.09
Concentrate Feed Mix	693.80
Least Cost Ration in Tons per ton of Milk Produced	
Fodder (Clover)	3045.26
Concentrate Feed Mix	462.84
Actual Feed Costs per Ton of Milk Produced ($):	
Fodder (Clover)	37.45
Concentrate Feed Mix	154.54
Total	191.99
The Value of the Least Cost Ration per ton of Milk Produced ($)	
Fodder (Clover)	45.60
Concentrate Feed Mix	103.10
Total	148.70
Expected Saving in Feed Costs on National Level (millions of US$)	169.29

Source: Estimated from:
(1) Equation (Equation 8)
(2) Prices shown in (Table 3)

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