INTERNATIONAL CONFERENCE

ON

AGRICULTURAL ENGINEERING & RURAL DEVELOPMENT

BEIJING CHINA

BEIJING UNIVERSITY OF AGRICULTURAL ENGINIREEING

OCTOBER, 1992

VOLUME 1

ISBN-7-80003-199-/S125

AGRICULTURAL MECHANIZATION AND ECONOMIC EFFICIENCY OF AGRICULTURAL PRODUCTION IN EGYPT

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INTRODUCTION

The frame of the agricultural mechanization plan in Egypt was established in 1979 [1]. It included three stages. The first stage (1980-1985) was allocated for liberalization of animal work from farming operations to increase meat and milk production. This stage had to reach a full service of land by the tractor for plowing and land preparation. The second stage (1985-1990) had an objective to liberate the human labor from direct work on land. This stage had to reach full mechanization of some additional farm operations such as harrowing between lines, harvesting of rice and wheat and cutting the green fodders. The third stage (1990-2000) have being allocated for full mechanization of the main crops as cotton, grains and fodders and disappear of water wheels "SAKIA" from rural area. The plan included a program to establish mechanization stations for demonstration and extension [2]. The program succeeded to provide extension , custom service and funds to purchase several types of machines. It also succeeded in establishing many small workshops and centers for maintenance. All these efforts and other supporting programs have mad© agricultural mechanization as one of the front issues of agricultural development in Egypt in this Era .

OBJECTIVES

The study concerned the achievements of five objectives. (1) The trend of the working power density in Egyptian Agriculture over the last decade; (2)Impacts of liberalization of livestock from farming operations, due to substitution for mechanization; (3) Effects of working power sources on major crops productivity; (4) Economic efficiency of physical technology versus biological technology in crop production; (5) Impacts of mechanization on employment rate in agriculture.

DATA BASE

To accomplish the given objectives a sample survey was conducted in 1987, which included the conventional farmers who have the same cropping pattern of the four major crops (wheat, Maize, Rice and cotton). Two villages from two regions were selected. The first region with agricultural mechanization station and the other one is far from such facilities. The sample was from Sharkia governorate. It is one of the major agricultural zones in Egypt, where the Zagazig University is providing its service. The farms within villages were selected to reflect proportionally the farm size classes. The total sample was 140 farms.

ANALYTICAL PROCEDURE

To reach the objectives a production (response) function was estimated for each of the four concerned crops on the farm level. The model was treated the econometric problems properly, particularly, the model specification multi co-linearity and goodness of fit. The best-fitted model was the Cobb-Douglas form. The dependent variable was the crop production per farm and the explanatory variables were human labor, machinery labor and animal labor as hours used per farm and an aggregate monetary variable that represented the biological technology seeds, fertilizers, chemicals, ...,etc.).Differences between crop yield of the two regions was not statistically significant. Therefore, there was no need to introduce a dummy variable in the estimated function to reflect the impact of the region on the crop production. On the other hand, the crop area was omitted from the estimated function to avoid the multi co-linearity between such variable and other concerned inputs, because thee was a high correlation between crop area and most of the other variables

TECHNOLOGICAL CHANGES IN AGRICULTURE OVER THE LAST DECADE

Comparison of the relative share of the working power sources in agriculture over the last decade showed that dramatic changes had been occurred (Table 1). The share of each source was estimated as HP per feddan per year. The index used was 1-hr of animal work=one HP, 1-hr of human labor work=l/6 HP and one hour of machinery work varies according to the type of machine (it ranges between 60 HP to 10 HP) .There was a significant positive trend towards mechanization from seventies to eighties. The share of machinery power increased from about 7496 in seventies to abut 90% in eighties. However. the bulk of this change was in terms of tractors. Whereas, human labor share stayed almost constant as an absolute figure, i.e. from 144 HP per feddan (4.200 m^{2}' in seventies to about 142 HP/feddan in eighties, its relative share decreased from 6.6% to *.3%.* The effective impact of mechanization expansion was on animal work. Its share decreased from about (429 HP/feddan) in seventies (13 HP/feddan) in eighties, i.e. from 20% to less than 5%, respectively.

IMPACTS OF LIBERATING LIVESTOCK FROM ANIMAL WORK ON MILK PRODUCTION

From estimated milk response function from field survey data (3 5.4) , it was concluded that the effect of animal work on milk production depended upon the type of the farm operation served by the animal . Livestock power used for plow or threshing work operations was the only type of farm operations that had significant negative impacts on milk yield. The estimated quantity saved of milk (4% fat corrected milk) per day due to *liberation of animals from such tough* work was 3.7 Kg . from a dairy cow and 5.1 Kg. from a dairy buffalo with a weighted average 45.76 Kg. per feddan. The derived quantity of milk that would have been saved on the national level was about 274 , 560 tons per year .

EFFECTS OF WORKING POWER SOURCES ON CROP PRODUCTIVITY

The estimated crop response function included the working power inputs in terms of human, animal and machinery labor as hours per farm per crop, as well as , a monetary variable that represents, the aggregation of the biological technology. These explanatory variables explain the variability in the farm crop production (the dependent variable Y of the estimated functions. The estimated form captured most of the variability in the crop production per farm, as the adjusted coefficient of determination ranged between 0.77 to .0.86. The signs of the estimates followed both the economic and technical logic. Table 2, shows the average level of the inputs and the outputs of each concerned crop on per feddan base.

$LnY_{(cottot0}$ =-2.51 + 0. 51*LnX_1 + 0.37*LnX_2 + o.01*LnX_3 + 0.01LnX_4,. R^{-2}= 0.86, N=120

$LnY_{(maize)}$ =-2.27 + 0.74*LnX_1 + 0.21*LnX_2 + 0.1*LnX_3 + 0.02LnX_4, R^{-2} =0.81, N=131

$LnY_{(wheat)}$ = -^{1} • $^{45\ +\ 0}$ • 13'LnXi+O . 43"LnX_2+ 0 . 36"LnX_3+0 . 07LnX_4 . . . R-^{2}=0 . 85-N= 125

$LnY_{(rice)}$ =- 3.09 + 0.25*LnX_1+0. 4*LnX_2 + 0.19*LnX_3 + o.09*LnX_4, R~^{2}= 0.77, N=125

While the biological technology variable (X_1), the human labor variable (X_2) and the machinery variable (X_3) showed significant effects on the farm production of all concerned crops (*= significant at P<.05), the animal work input (X_4) had insignificant effect on the farm production of cotton, maize and wheat. The only crop production that showed a positive significant response to animal work was the rice production, where 10% increase in animal work will increase the rice production per farm by only l-percentage. This is because several operations for rice production have not yet received the proper custom service.

ECONOMIC EFFICIENCY OF PHYSICAL TECHNOLOGY VERSUS BIOLOGICAL TECHNOLOGY

The economic efficiency of the four concerned inputs of the estimated crop responses was estimated from the following derived model:

(1) Marginal physical product of input X_i= (MPP_i)= b_i ($û_y$/ $û_x$)

(2) Value of marginal physical product of input X_i = marginal return of input =

X_i= ($VMPP_i$) = P_y (MPP_i) = P_y

(3) Economic efficiency of input X_i = ($VMPP_i$)/ P_i = (P_y/ P_i) [b_i ($û_y$/ $û_x$]

Where: b_i = estimated regression coefficient of input X_i $û_y$ and $û_{xi}$, are the average yield per farm and the average level of input i, respectively: and P_y and P_i are the average free market prices of output and input i, respectively.

It should be mentioned, that the price per unit of one hour of machinery is the operation cost per equivalent-tractor hour without fuel subsidy and for human labor; it is the average wage rate in the market. For animal work, it is the rent rate of one equivalent hour of a camel. Both human labor and animal work, have being free market in spite of the concerned period. For the aggregate monetary variable that reflect the biological technology, it *is* considered as the opportunity cost of capital, which is calculated as one Egyptian pound plus the free market interest rate (e.g., in 1987 it was 17%)

Table 2, shows the estimated average economic efficiency of each input among the four crops. It is the average return per additional pound spent for a given input. From Table 2, and among working power sources, agriculture mechanization for cotton was the labor input of the highest economic efficiency, followed by wheat. It surpassed the efficiency of the other two labor inputs. Economically, it is recommended to expand its level at the expenses of human labor and animal work for the production of these two crops. The economic efficiency of the three labor inputs for maize was less than one, and in fact it was *zero* for animal work.

Therefore, the priority to increase the production of maize (vertically) should be given to the biological technology package. After reaching a reasonable higher level of maize yield, due to the biological technology, it may be possible to intensify the mechanization level for such crop. Rice was the only crop that showed an economic efficiency of using animal work. Although the other labor inputs showed also an economic efficiency more than one for such crop, surprisingly, animal work had the highest efficiency of the three labor inputs. However this is because up to 1987 (the surveys date) there were several farm operations that have not being mechanized yet.

Under limited capital availability for financing the development of crop production, the priority of investment should be given to the technological package of the highest economic efficiency. Among the four concerned major crops the biological technology package for cotton, rice and maize showed the highest economic efficiency, in comparison with mechanization. Therefore, such package should receive the core of attention of investment for agricultural development. However, mechanization for wheat production showed the highest level of efficiency among all other applied inputs. Accordingly, under lack of funds the planner should give priority to wheat mechanization in order to expand its production on the short run.

Probably, some views would see that once both biological and mechanization packages for cotton, maize and rice have on the average an economic efficiency more than one, it is not recommended to limit the investment within the biological or the physical technology package. However, it is more important to orient the producers towards the best efficient package through the price policy and/or the credit policy

IMPACT'S OF MECHANIZATION ON EMPLOYMENT RATE IN AGRICULTURE

Under free market price policy, the optimum allocation of working powers in agriculture towards maximization of profit requires the application of the least cost - combination of these powers for crops on farm. This decision implies some socio-economic problems. One of these problems is the expected shrinkage in human labor intensity, which will cause additional increase in the unemployment rate, due to the replacement of a proportion of the currently used agricultural human labor for machinery work. Therefore, the demand for investment to create new jobs for those unemployed people will be an extra challenge.

The study used the estimated crop-response functions of the four major crops to derive the Isoquant curves function and applied the Isoclines functions at unsubsidized machinery operation costs and market wage rate. The derived Isoquant function for each crop is as follows:

Cotton: $X_2 = [Y/ (0.563X_3^{0\ 10})]^{2.7}$

Rice: $X_2 = [Y/ (0.147X_3^{0.19})]^{2.5}$

Maize: $X_2 = [Y/ (2.19X_3^{0.10})]^{4.76}$

Wheat: $X_2 = [Y/ (0.42X_3^{0.36})]^{2.12}$

The least cost combination of both the human labor and machinery were derived at the average yield of each crop. A comparison was made between the level of both inputs at the least cost combination and the status. It was found that there will be a surplus in human labor , associated with additional machinery work to be applied. To generalize the results on the national level, the expected change in both inputs were adjusted to be Man-Year equivalent of human labor and to be HP of mechanization. The weights were 6 hours work per man per day and 50 HP per equivalent tractor hour. The adjusted changes in both inputs were weighted by the production period of each crop and the total area occupied by each crop . The total area under cotton, rice, maize and wheat were 1,081,009 feddans, 984.839 feddans, 1,914,433 feddans and 1,859,200 feddans, respectively. It is concluded that the aggregate human labor to be saved and the additional mechanization inputs required to reach the optimum economic efficiency of the four crops, under free market price policy will be 175,000 man- year and 128 millions HP of machinery work. These figures will be much more if we considered the total cropped area in Egypt, which is about 12 millions feddans. Therefore, abundant volumes of funds are required to create employment opportunities for the surplus of agricultural labor and to invest in the establishment of manufacture industry for the required agricultural machineries. The private sector is currently taking the initiative to establish such industry. Transforming training is an approach to utilize the expected human labor surplus.

CODAL NOTE

The planner, either on the micro level (farm level) or macro level (national level) faces a multi-objective decision making when orienting the agricultural development towards the appropriate technology particularly in developing countries. Therefore, there should be adequate criteria for assessment and clear view of the major constraints. Among these, constraints is the infrastructure level and quality. The resistance of using animals for transportation in the village is due to narrow twisting roads and small fragmented farm holdings with dispersed plots of the farm holdings, associated with multi-crops pattern and small individual proportions for sale. These patterns in the village enforce the small farmers to keep draft animals for transportation, even though they consume *a* considerable proportion of feeds, which are very limited and expensive.

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Table 1 Trend of working power intensity for agriculture by type

Type of working power	HP per feddan per year			
	In 70's*		In 80's**	
	HP	%	HP	%
Human labor	144	6.6	142	5.3
Animal work for farm	77	3.6	28	1.1
Animal work for	352	16.3	98	3.7
Total	429	19.9	12	4.8
Tractors work	400	18.5	890	33.5
Other machines	1190	55.0	1500	56.4
Total	1590	73.5	2390	89.9
Gross horse power	2163	100	2658	100

(*) Deducted from reference No. 3

(**) calculated from the survey's data of this study

Table 2 Sample average of area, yield and inputs density per feddan of the four concerned crops.

Item	Cotton	Rice	Maize	Wheat
Crop area (fed.)	2.24	2.26	1.86	1.9
Tons/fed	1.1	2.38	1.42	1.27
Human labor*	530.1	294.6	270.4	141.9
Machinery Work*	13.2	32.2	12.9	9.8
Animal work*	6.6	14.3	5.8	6.9
Biological technology, L.E.**	45.3	42.3	63.5	30.8

Fed, = feddan, which is 4.200 m^2

* = hours per feddan

** = an aggregate variable in monetary term, where L.E. = Egyptian pound

Table 3 Economic efficiency coefficient of working power sources by type and by crop

Crop	Economic efficiency in L.E.			
	Biotechnology	Human Labor	Machinery Labor	Animal Work
Cotton	40.1	4.2	7.5	00*
Maize	3.9	0.5	0.81	0
Rice	8.2	3.2	2.31	6.91
Wheat	1.5	2.07	4.14	0

* Economic Efficiency = 0 when the animal work productivity estimate was insignificant