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Economic Efficiency Estimation for Human Labor and Nitrogenous Fertilizers Applications in Vegetables Production: A Case Study of Some Major Vegetables Production, Giza, Egypt

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ABSTRACT

The study revealed costs of production as a crucial factor limiting applications of either fertilizers or human labor below economic efficient standards. Applications approached full efficiency for labor where reliance upon family labor prevailed, except wherever skilled labor is imperative. Producers were obliged to apply nearly sufficient quantities of nitrogenous chemical fertilizers whenever manure is not used. Moreover, small producers who have to rely on market for acquiring their manure needs apply quantities much less than efficient standards. Accordingly, it was concluded that technical guidance would not be effective for efficient applications as long as production budgets are stagnant.

Key words: Economic production efficiency, agricultural production inputs, marginal product, average product

Introduction

The microeconomic theory presents concepts and rules of inputs' package application in production activities to achieve maximum profit. Nevertheless, following such rules is hardly expected in reality since mostly relying on algorithmic formulas beyond grasp of most either producers or extension agents. Moreover, such rules may be applicable under conditions varied from those under which many producers operate, such as climatic and land fertility in farming activities. However, uses in the opposite direction may be applicable. Instead of guiding farmers to practices fulfilling maximum efficiency conditions researchers may judge producers' actual practices efficiency wise. The last represents the purpose of this study with special emphasis upon production of some major vegetables in Giza governorate, Egypt.

Problem

Although Egyptian farmers seek maximum profits they are mostly unaware of the specific economic condition of inputs application fulfilling such target. They are mostly influenced by relative changes in inputs prices regardless of actual contribution of each input in production. Since economic assessment of such practices is hardly available so far little can be provided in farmers' guidance toward maximum efficiency applications.

Objectives

The study tends to estimate the efficiency of labor and nitrogenous fertilizers use in production of tomatoes, potatoes and onions representing major vegetables produced in Giza governorate, Egypt. Several studies revealed the special importance of human labor and nitrogenous fertilizers as influential factors of production of the selected crops such as (Abd El Al and Hafez, 2004; Abd El-Latif, 2005) . The study's task is considered useful for farmers' guidance toward changes in inputs applications fulfilling higher production economic efficiency.

Methodology

The sufficient rule for full economic efficiency of inputs applications is equating the value of marginal product for each input with its unit price:

$MP_{xi} .P_y = R_{xi}$ or MP_{xi} / R_{xi} equal for all x_i (Awh ,1976; Cole , 1997; Dewett, 2015)

Where; MP_{xi} = marginal product of x_i , Py = price of the product, and R_{xi} = unit price of x_i.

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Accordingly, any deviation from such rule is deduction from efficiency. As such, the study suggests the following equation as an estimator of economic efficiency (EEf_{xi})

$EEf_{xi} = 1 - (| MP_{xi} .P_y - R_{xi} | / R_{xi})$ or

$EEf_{xi} (\%) = 100 - 100 (| MP_{xi} .P_y - R_{xi} | / R_{xi})$

That is, the economic efficiency of an input is the ratio of the absolute difference between the input's marginal product value and its price relative to the last subtracted from unity, or the percent ratio subtracted from 100.

The marginal products are derived from production functions estimated on data obtained through a stratified random sample survey (2011-12) of variant landholdings strata of vegetables producers in Giza governorate with a sample size of 180, of which 66, 70 and 44 produced tomatoes, potatoes and onions, respectively(El-Batran,2015) . The production functions were estimated using step-wise regression analysis in statistically best fit mathematical forms. Giza governorate was chosen due to its relative importance in vegetables production.

Results and discussion

Estimated economic efficiency applications:

The Cobb-Douglas logarithmic form was found statistically best fit for the selected crops, featuring lowest unexplained variance (highest determination coefficient).

The average marginal products for the two inputs are estimated according to

$MPx_i = b_{xi}\ Y^*/ X_i^*$ (Monga,1975), where; b_{xi} = regression coefficient of Y on X_i , Y^* and X_i^* are averages of Y and X_i , respectively.

Table (1) presents the study's estimates of averages for average product, marginal product and economic production efficiency for the selected crops and inputs.

Tomatoes:

a. Equation (1) presents the estimated production response function of tomatoes for the whole sample.

$LnY_i = 7.91 + 0.128\ Ln\ NIT_i + 0.191\ Ln\ LAB_i$ $R^2 = 0.64$ (1)

(24.0) (3.2) (4.3)

Where; Y = amount of production (kilograms), NIT = applied amount of nitrogenous fertilizer (effective element units), LAB = labor work (man/days). Figures between brackets are "t" ratios.

Accordingly, as shown in table (1), averages of MP_{NIT} and MP_{LAB} were estimated at 5.97and 32.8 kg, respectively. The efficiency equation was applied using unit prices for the product and the two inputs. The economic efficiency estimates for nitrogenous fertilizer and labor were estimated at 83% and 64.3%, respectively in an average for the whole sample. For both inputs the price was higher than the average marginal product value the inputs, hence applications should be decreased in order to achieve higher efficiency.

Equation (2) represents the production response function for the sample of producers on areas of less than 0.5 ha each

$Ln\ Y_i = 7.57 + 0.219\ Ln\ NIT_i + 0.178\ Ln\ LAB_i$ $R^2 = 0.59$ (2)

(13.9) (4.2) (2.6)

From table (1), the average efficiency for N. fertilizer was estimated at 85% but dropped for labor to nearly 44%. Involvement of family labor may explain the excess of labor used for such so small areas.

Table 1: Estimates of average and marginal products and average economic efficiency for labor and nitrogenous fertilizers for the sample of vegetables producers

Crop	Area Stratum	Input	Average product (kg)	Marginal product (kg)	Average efficiency (%)
Tomatoes	≤ 0.5ha	Nit.	45.0	9.85	85
		labor	151.3	26.9	45
	General	Nit.	46.6	5.97	83
		labor	171.9	32.8	64
Potatoes	≤ 0.5ha	Nit.	52.2	9.5	32
		labor	192.3	44.4	90
	General	Nit.	51.9	10.5	15
		labor	283.6	60.7	49
		manure	322.6	23.2	56
Onions	0.5 – 1ha	Nit.	57.9	14.0	54
		labor	199.5	60.9	89
		manure	327.5	51.0	14
	General	Nit.	65.4	64.0	80
		manure	362.3	33.3	68

Source: study estimation.

Potatoes:

Equation (3) represents the production response function for potatoes to the selected inputs, also in the logarithmic form.

$$\text{Ln } Y_i = 7.5 + 0.072 \text{ Ln } Mn_i + 0.203 \text{ Ln } NIT_i + 0.214 \text{ Ln } LAB_i \qquad R^2 = 0.61 \qquad (3)$$

(17.6) (2.1) (4.4) (3.4)

Where Mn_i = manure application (m^3), and other variables same as for equations (1, 2 and 3).

Accordingly, the estimated average economic efficiency of labor use was about 49%. As for N. chemical fertilizers and manure, average economic efficiency was estimated at 15.4% and 56.1%, respectively. High prices of chemical fertilizers may explain the dramatically low application of the N. fertilizer, leading to the remarkably low economic efficiency.

The situation seems considerably different for producers of small areas falling below 0.5 ha each as estimated from equation (4)

$$\text{Ln } Y_i = 7.14 + 0.183 \text{ Ln } NIT_i + 0.231 \text{ Ln } LAB_i \qquad R^2 = 0.62 \qquad (4)$$

(11.1) (2.4) (2.8)

According to equation (4), the average efficiency for labor use rose to nearly 90%, while the corresponding estimate for chemical N. fertilizer almost reached 32%. Such results may be explained by reliance on non- paid family labor on one side, and relatively low cost of fertilizers for such small areas on the other side. However, N. fertilizer's application seems still far from being fairly efficient.

Onions:

Equation (5) presents onions production response function to changes of the selected inputs for the whole sample of producers

$$\text{Ln } Y_i = 7.90 + 0.092 \text{ Ln } Mn_i + 0.223 \text{ Ln } NIT_i - 0.053 \text{ Ln } INS_i \qquad R^2 = 0.68 \qquad (5)$$

(38.0) (2.5) (3.7) (-2.9)

Where INS_i = value of applied insecticides

According to equation (5) and table (1), the average efficiency of manure and chemical nitrogenous fertilizer reached 80% and 68%, respectively. The higher efficiency for manure could be explained by its cheaper cost. The insignificant response to labor might be due to producers' reluctance toward employing more men for greater cultivated areas. On the other hand, the negative sign of the value of insecticides' impact may indicate exaggeration of application afflicting the produce in both quality and volume (third phase of production).

Equation (6) presents onions production response to the considered inputs for the sample of producers of areas within (0.5 – 1) ha

$$\text{Ln } Y_i = 8.14 + 0.156 \text{ Ln } Mn_i + 0.243 \text{ Ln } NIT_i + 0.305 \text{ Ln } LAB_i \qquad R^2 = 0.95 \qquad (6)$$

(35.5) (4.5) (6.8) (2.7)

As shown in both equation (6) and table (1), a very different situation occurred. That is where the average efficiency of nitrogenous fertilizer dropped to nearly 54% and dropped dramatically for manure to less than 14%. That is while the labor's working days regained its impact with an average efficiency reaching 89%. Most likely, reliance on family labor not actually paid for may explain sufficient employment. On the other hand, small landholders rarely keep sizable herds of livestock, and accordingly have to rely on market for acquisition of their manure needs.

Percentages of producers adopting efficient inputs doses

The study tended to estimate the proportion of producers operating at maximum efficiency of inputs applications. In this respect, it was found mathematically easier to calculate the full efficient average product than the marginal product from the natural logarithmic form estimated for the production response functions. As such, said average product $(y/x)^* = R_{xi} / (b_{xi} \cdot P_y ,)$ based upon the mentioned early economic efficiency equation. Table (2) presents the percents of producers applying at least 90% of full efficient applications of human labor and nitrogenous fertilizers.

Table (2) shows that percentage of efficient small producers is high in labor use for both potatoes and onions production, but remarkably low for tomatoes. It might be explained by reliance on family labor, except for tomatoes which requires skilled labor for specific farming operations. An opposite condition occurs for chemical nitrate fertilizer as efficient application is observed for both categories of tomatoes producers, as entirely depending on this input not using manure. On the contrary, using manure may have led to lower than needed application of chemical fertilizers for production of potatoes and onions. As for manure, relying on market may explain less than efficient application for small producers in particular.

Table 2 : Percentage of farmers producing at 90% or more of full efficiency in inputs applications

Crop	Area stratum	Labor (y/x)*±10%	%	Nitrate fertilizer (y/x)*±10%	%	Manure (y/x)*±10%	%
Tomatoes	≤ 0.5ha	309 - 378	28	35.4 – 43.2	77	-	-
	general	192 - 234	38	40.2 – 49.1	74	-	-
Potatoes	≤ 0.5ha	157 - 192	79	28.0 – 34.0	27	-	-
	general	171 - 209	34	25.7 – 31.3	15	241 - 295	34
Onions	0.5 – 1ha	160 - 196	80	36.2 – 44.2	33	205 - 250	15
	general	-	-	39.5 - 48.3	32	272 - 332	47

Source: study estimations.

Conclusions

Costs of inputs seem to be the crucial factor of efficient application for either labor or fertilizers. Efficient use of labor generally occurred for small producers as relying upon family labor except for operations needing skilled labor. When relying on chemical fertilizers, producers have to apply sufficient doses, different from the situation where organic fertilizer (manure) is used. On the other hand, small producers seldom keep livestock providing sufficient manure, and hence, having to rely on purchases. Accordingly, cost of such purchases force producers to limit applications in most cases.

In view of these respects, technical guidance toward efficient inputs applications would not be sufficiently effective as long as production budgets do not increase. This holds for most Egyptian farmers who are in majority small producers by normal standards.

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