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RESOURCE-USE EFFICIENCY OF MILLET PRODUCTION UNDER SALINITY CONDITION IN NORTH SINAI GOVERNMENT, EGYPT

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ABSTRACT

North Sinai farming community is facing many challenges such as increasing drought and salinity in water and soil, poor quality soils, a long hot summer with high solar radiation; in addition to poor experience of settled farmers and local Bedouins in improving traditional agriculture and animal productivity under saline conditions. The main objective of the study is to establish the efficiency of resource use in millet production among smallholder farmers in North Sinai region. Using a multi-stage random sampling procedure in selecting farmers interviewed. A structured questionnaire was administered to 60 smallholder farmers selected for analysis; the farmers were divided into two groups based on ownership and use of animals on the farm, and used a model to evaluate efficiency of the two groups. In this model, a Cobb-Douglas production function was fitted for the cross- sectional data generated from the survey. The ratio of marginal value product (MVP) to marginal factor cost (MFC) for all inputs was found to be greater than unity among all groups of farmers implying under-utilization of resources. Millet farmers were found to experience increasing returns to scale, meaning use of additional inputs in millet production would result in higher yields. The null hypothesis, which stated that smallholder farmers in North Sinai region are not allocating their farm resources efficiently in millet production, was tested and rejected at 5% level of significance. It was therefore concluded that millet farmers in North Sinai region were sub-optimally allocating resources in their production system.

INTRODUCTION

Egypt is located in the northeastern corner of Africa; it extends to approximately one million km^2 in size. Egypt's climate is semi-desert characterized by hot dry summers, moderate winters and very little rainfall. Environmental degradation resulted from current climate changes, including prolonged drought, land degradation, desertification and loss of biodiversity, is presenting enormous challenges to achieve food security and eradication of poverty in the marginal regions [1].

Populations in Egypt are growing so quickly (approaching 90 million people) that the arable lands and the available fresh water are unable to sustain the population increments. Salinity that leads to desertification is a serious problem with a crucial impact on agriculture development in particular in arid and semi-arid zones of Egypt [2].

Because of the climate change and other human factors, Egypt is far from being self-sufficient in some food materials. Livestock constitutes an important component of the agricultural sector, representing about 24.5% of the agricultural GDP with value of around US$ 6.1 billion [3]. The amounts of feed produced were decreased due partially to the impact of climate changes on feed ingredients cultivation. The natural vegetation, as the principle feed resource in the Egyptian deserts is seasonally and drastically variable depending on rainfall. The yield of this vegetation, as animal feeds, does not cover the annual nutritional re-

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quirements for animals. It became necessary to find an alternative sustainable source of feed resources, especially forage crops. Therefore, utilization of salt affected soils and saline / brackish water resources for forage production could be a potential approach for alleviating the impact of climate changes in marginal areas in Egypt. It is believed that cultivation of salt-tolerant crops, using marginal resources such as saline soils and irrigation water has significant social and economic potential to solve the problems of food for human and animal feed shortages and decrease its costs [4]. These plants can grow in saline to extremely saline habitats and have particular characteristics, which enable them to evade and/or resist and tolerate salinity by various eco-physiological mechanisms.

Pearl millet is a widely grown rainfed cereal crop in the arid and semiarid regions of Africa and southern Asia. Areas planted with pearl millet are estimated at 15 million hectares annually in Africa and 14 million hectares in Asia. Global production exceeds 10 million tons a year. In other continents it is grown under intensive cultivation as a forage crop. In addition to tolerating hot and dry climates, pearl millet is able to produce reasonable yields on marginal soils, where other crops would fail. Low fertility and high salinity are frequent problems in millet producing areas. At the same time, pearl millet responds very favorably to slight improvements in growing conditions such as irrigation and tillage [5]. For these reasons it has the potential to spread to more areas of the world, namely the semi-arid zones of Central Asia and the Middle East, North and South America, and Australia [6]. The farmers are using inputs especially agrochemicals indiscriminately due to lack of standardized production technologies for this region. Although they are getting higher yields but the profit margin could be increased by using cost-effective technologies. Farmers are also not homogenous with respect to their behavior in using resources optimally. Under this premises, an attempt was made to analyze the resource-use efficiency of the millet growers and the requirements in adjustments for optimum utilization of resources for millet cultivation.

Description of Region

North Sinai region

El Tina plain (so-called Sahl El Tina) area, sized 50 thousand acres, was selected for the study activities to represent the marginal ecosystem of North Sinai region. The poverty and inappropriate management practices are common among the local farmers; besides the marginal (saline) soil and water resources are the problems of agriculture development in this area. It was chosen to carry out the activities of the study on the farm level. It is located at the eastern side of the Suez Canal; characterized by semi- arid condition (annual rainfall is about 16o mm / year). The soil texture, in brief, ranges from sandy loam to clay; the water table levels range from 5 cm to 70 cm, where soil salinity ranges from 33.3 to 46 $dS.m^{-1}$ and exchangeable sodium percentage range from 10.4 to 67.0%, indicating that the soil is moderately salty to very sever salt affected. In addition, the soil is characterized by poor fertility, where organic matter content and nutrient levels (N,P,K) in the surface layer (0-30 cm) ranges between 0.08 and 0.38 %, 08 to 0.22%, 0.21 to 1.4 me/100g soil, and 8 to 20 ppm , respectively. It is clear that all of these nutrients lie in deficiency levels. The mixed Nile water (from El Salam Canal) is used for irrigation with salinity ranges between 1.6 -2.3 dS/m (1024-1472mg/L), respectively. The common irrigation system is flood irrigation but the participated farmers who contributed and benefited in the project activities are applying drip irrigation and/ or sprinkler irrigation systems.

Sources of Data

The study used both primary and secondary data, Secondary data were used particularly where time series data was obtained from past research works and government reports. Primary data was obtained from a farm survey of smallholder farmers in North Sinai region. The survey covered a sample of small-scale farmers within the district. A structured questionnaire was used to extract information from the respondents.

Sampling and Data Collection

The data pertaining the crop season of 2014-2015 were collected on different factors influencing the Pearl millet cultivation with the help of pretested, semi-structured interview schedules by conducting personal interviews, group discussions, field and empirical observations. A multi-stage stratified random sampling procedure was used in selecting the study zones. The multi-stage sampling procedures were followed in four divisions of the North Sinai region. A list of all the locations in the relevant was obtained, and from it, two locations were randomly selected. In each location selected, a list of all the sub-locations was again drawn and one sub-location was selected for sampling. All the villages in the selected sub-locations were listed and one village was randomly selected. Finally, a list of all the farmers in each village selected was compiled with the help of the village elders, and the farmers to be interviewed were randomly selected from such villages. This same process was repeated for all the four divisions. A minimum of sixty farmers were selected and interviewed in each division.

MATERIALS AND METHOD

Analytical Framework

Due to lack of market information regarding prevailing prices of the Pearl millet and its arrival etc., most of the producers marketed their produce in the village itself, without waiting for the better market opportunity. A non-frontier production function was fitted to the data to measure the technical efficiency of smallholder millet farmers. The Cobb-Douglas (CD) type of production function was used in this study as it is most widely used in the agricultural research and is convenient for the comparison of the partial elasticity coefficient [7]. Following the works of [8], a Cobb-Douglas form was estimated. The model used was specified implicitly as follows:

$Q= f(X_i , D , u)$……………………..…………..……..(1)

In an explicit Cobb-Douglas form:

$Ln\ Q= A_i + b_1X_1 + b_2X_2+ b_3X_3+e+ b_4D_1 + b_4D_2 + eu$……………………..………..…………………..…….(2)

(i= 1,2)

In log linear form:

$Ln\ Q= LnA_1 +b_1\ LnX_1 + b_2\ LnX_2 + b_3\ LnX_3 + b_4 D_1+b_4 D_2+ u$……………………………..………(3)

$Ln\ Q= LnA_2 +b_1\ LnX_1 + b_2\ LnX_2 + b_3\ LnX_3 + b_4 D_1+b_4 D_2+ u$……………........………………..…..(4)

Where:

- Q= Quantity of bulrush millet output (ton/ fadden)
- X_1= labour used in production (men/ fadden)
- X_2= Value of capital inputs except labour (LE/ fadden)
- X_3= Experience of the farmer (Years)
- D_1= Dummy for bulrush millet planted (1= improved Transactions; 0= local Transactions)
- D_2 = Dummy for formal education of the farmer (1= educated, 0 = otherwise)
- A_1= Efficiency parameter for farmers who own animals
- A_2= Efficiency parameter for farmers who do not -own animals
- u = Random error term (Statistical 'noise').
- b_i = Regression coefficient (i=1, 2, …..............,5)

The ordinary least square (OLS) estimation of the above model was done using the Statistical Package for Social Sciences (SPSS).

Resource-use Efficiency

Resource use efficiency was obtained from the production function analysis. Efficiency is generally defined as the quantity of output (y) per unit of input (x) used in production process, that is the average physical productivity (APP), in order to ascertain whether resources were efficiently utilized.

The marginal value product (MVP) of the variable inputs used was computed and compared with their input prices. The following ratio was used to compute the efficiency of resource use [9]:

R= MVP/MFC ……here,

R = Efficiency ratio

MVP = Marginal value product of a variable input.

$MVP= MPP_{xi}\ P_y$

$MPP_{xi} = \delta Y / \delta X_i$

MPP = is a marginal physical product of a unit of input X_i.

P_y = is the price of output

MFC = Marginal factor cost (price per unit input). The marginal productivity of a particular. However, the denominator will always be one, and therefore, the ratio will be equal to their respective MVP [10]. According to the conventional neoclassical test of economic efficiency, a production input is being used efficiently if the ratio of the MVP of an input and the unit price of the input equals unity…………………….…. Thus,

a) If r <1, it means the resource in question was over utilized hence decreasing the quantity used of that resource increases profit.

b) If r > 1, it shows that the resource was being under utilized and increasing the quantity of use will raise profit level.

c) If r = 1 it means resource was being efficiently utilized.

The relative percentage change in MVP of each resource required so as to obtain optimal resource allocation that is, r = 1 or MVP = MFC, was estimated using the following equation:

$$D= (1–MFC/MVP)\times100=(1–r–1)\times100$$

Where:

D = Absolute value of percentage change in MVP of each resource.

RESULTS AND DISCUSSION

Production function analysis

The production function that was used to determine the nature of input relation in millet production is shown in **Table (1).** Production function was chosen as the lead equation based on the statistical criteria, the value of coefficient of determination (R^2) indicated that 98, 85% of the variation of output of millet production for both owner (with animal, without animal) was explained by the regression model, respectively. The regression coefficient for owner with animal of labor (X_1), Value of capital inputs except labor (X_2), Experience of the farmer (X_3), Dummy for millet planted (X_4) and Dummy for formal education of the farmer (X_5) were positive indicating that an increase in these inputs, holding others constant will lead to an increase in the output. Meanwhile the regression coefficient for owner without animal not significant.

Except, labor(X_1), Value of capital inputs (X_2), Experience of the farmer (X_3), were indicating that an increase in these inputs, will lead to an increase in the output.

The sum of the production coefficients of the factors in millet production estimating equation, when the dummy variable is Excluded, has been calculated as (∑βi) 0.27, 0.6 for both groups (animals owners, without animals owners) respectively. This value can be interpreted, as 10% increase in the inputs will lead to 2.7%, 6 % respectively, increase in millet production amount on condition that the combination of the independent variables remains stable [11].

8. Allocative Efficiency in Millet production

To determine the allocative efficiency of resource use in millet production in the study area, the marginal physical product (MPP), marginal value product (MVP) and the ratio of to marginal factor cost (R) were calculated. The result of production function equation above in **Table (1)** was then multiplied by the average price per Ton of millet for the period to arrive at the MVP for each factor input.

Results show that for the farmers who own animals the MPP for labor (x1) and capital (x2) are 0.29 and 0.003 of millet per Fadden respectively. This suggests that, on average, and with all other factors held constant, a unit increases in labor and capital utilization by the animal's owners would increase millet yields by 0.29 ton and 0.003 ton per Fadden respectively. For farmers without animals, a unit increases in labor employment and capital would result into 0.16 ton and 0.006 ton increase in millet output per fadden respectively **(Table 2).** According to the MVP, figures derived for each input by farmer category, the return from an additional person-day of labor input employed in millet production is approximately LE 58, LE 32 to farmers who own animals and farmers without animals respectively, an additional one LE used in millet production would bring a return of about LE 0.6 to an animal owner and LE 1.2 to a non-animal owner farmer.

Table 1. Parameters and test values of Millet production function/ Fadden

	Owner With animal			Owner without animal		
	Elast. Coeff. (βi)	"t- value"	Sig.	Elast. Coeff. (βi)	"t- value"	Sig.
Constant	0.563	6.49	0.000	- 0.155	0.251	0.803
X_1= labor	0.047	3.615	0.000	0.0328	2.312	0.000
X_2= Value of capital inputs except labour	0.17	8.086	0.000	0.406	5.872	0.000
X_3= Experience of the farmer	0.05	3.827	0.000	0.149	2.92	0.004
D_1=Dummy for millet planted	0.012	2.599	0.011	- 0.089	1.38	0.170
D_2 = Dummy for formal education of the farmer	0.049	9.534	0.000	0.00013	0.004	0.997
R^2	0.98			0.85		
F	1373.4*			112.4*		

Source: Computed from field survey data, 2014

Table 2: Factor Marginal Physical Product (MPP) and Marginal Value Product (MVP) and Ratio of MVP to Marginal Factor Cost (MFC).

Variables	Farmers who own animals			Farmers without animals		
	MPP (Ton)	MVP (LE)	(R)	MPP (Ton)	MVP (LE)	(R)
Labor	0.29	58	149	0.16	32	235.2
Capital	0.003	0.6	1.5	0.006	1.2	8.8

Source: Computed from field survey data, 2014

These results suggest that farmers with animals receive relatively higher returns to labor input than the owners without animals do. To determine whether the farm resources were being used at efficient levels (allocative efficiency), the MVP's for each input was divided by the input's marginal factor cost (MFC). All the resulting ratios are greater than unity for all resources (capital and labor), indicating that these resources were being under-utilized on the sample farms by both groups of farmers during the survey year. The ratio for the labor resource is relatively higher for farmers without animals than those for animal's owners' farms **(Table 2).** The implication is that although both animal's owners and farmers without animals are under-utilizing labor, there exists greater underemployment of this resource in millet production among the farmers without animals. This state of affairs is attributable to the reduced labor demand among animals owners due use of animals on millet farms. The evidence of under-employment of labor in millet production by both groups of farmers expounds the widely held belief that millet production is labor intensive. The under-utilization of labor among animal's owners can also be explained by below capacity utilization of animals on millet farm operations. This further implies that the rise in labor productivity due to use of owned animals has not been fully exploited by the farmers who own animals. In general the below capacity utilization of resources (labor and capital) is attributable to the fact millet production among farmers in the study area is taken as a way of life with most producers only concerned with maximizing varied social objectives. In concluding this section it is worth noting that although farmers who own animals are relatively technically efficient in millet production, there tends to be suboptimal allocation of resource within all the sample farms in the study area.

Conclusion and Recommendations

The importance of the objective of this study was to establish resource use efficiency in millet production among smallholder farmers in North Sinai region. Our analyses show that both labor and capital inputs is a statistically significant positive determinant of smallholder millet production for the two groups of farmers. The management proxy variables (experience, millet planted and education) are statistically significant factors in smallholder for animal owners, meanwhile, non-significant in second group (without animals) except experience factor. The technical efficiency for the animal owners was found to be relatively higher than that of the farmers without animals. The ratio of MVP to MFC for all inputs was found to be significantly greater than unity for all groups of farmers implied under-employment of resources. From the aforementioned result, we conclude that millet farmers in North Sinai are sub optimally allocating resources in their production system. Labor and capital together are under-utilized by all farmers. Technically animal's owners are relatively more efficient than the farmers without animals meaning that the use of animals on millet farms raises farm-firm efficiency in millet production. Nevertheless, there exists a potential for increasing millet output levels by all farmers in the region through the application of additional inputs. Being a labor-intensive food crop, increased production would help in meeting the twin objectives of food security and employment creation in an area with unreliable weather patterns such as North Sinai region. For an optimal resource allocation and enhanced efficiency in millet production, farmers who own animals should be encouraged to intensify animal usage through employment in millet field operations such as weeding and planting of millet farms. Farmers who own animals and are unable to hire services should be encouraged to increase their labor use levels in millet production. This will ensure full exploitation of the potential that exists for increasing millet productivity in the region.

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