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Some factors affecting the efficiency of potato production, under Al–Ghab plain conditions, Syrian Arab Republic

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Abstract. Data were collected by a field survey of 300 farmers from Al–Ghab region (Syria) during 2014–2015. The non–parametric Data Envelopment was used in analyzing the Technical efficiency. The relationship between farm size and production efficiency was considered. Technical efficiency amounted about 53% and most of farms are operating at low level of technical efficiency. The relationship between farm size and productivity efficiency is Non–linear, it decreases from small to medium farm size and then increases as the size increase. Large farms have the higher net farm income per thousand square metersand are the most efficient technically followed by small and medium farm size. To disclose that factors causing the technical efficiency, Two–limit Tobit Regression Model was used. The calculated results showed that, Household Size, Occupation, Farm Size, Experience in Farming, Seed Type and Membership are factors that cause the technical inefficiency potato farming at Al–Ghab region. Therefore, the Syrian Planning Board and Decision Makers should take this results into account when they draw their plans to improve farmer's skills by allocating more investment in farm research and extension programmers.

Key words: Potato, Technical inefficiency, farm size, Data Envelopment Analyses, Tobit Model.

INTRODUCTION

Agriculture is one of the most important sector in the Syrian economy, as it employs about 21% of the labor force and generates about 25% of the country's gross domestic product (GDP). It has a decisive role in restoring food security, protecting natural resources, fostering economic growth and employment. Land use in Syria is divided into 45% desert and semiarid land, 32% cultivated land, 20% uncultivated, and 3% forests (Khaldoon & Berndtsson, 2012).

Agriculture is a high priority in Syria's economic development plans, as the government seeks to achieve food self–sufficiency, increase export earnings, and halt rural out–migration. Thanks to sustained capital investment, infrastructure development, subsidies of inputs, and price supports, Syria has gone from a net importer of many agricultural products to an exporter of cotton, fruits, vegetables, and other foodstuffs.

One of the prime reasons for this turnaround has been the government's investment in huge irrigation systems in northern and northeastern Syria (MAAR, 2010).

Similar situation is in other Middle East countries where governments attempt to diversify the economy by supporting other sectors by implementing different types of investments (Maitah et al., 2013; Maitah et al., 2015). Governments in the Middle East attempt to attract foreign direct investment to their countries, similar activities are done by European countries. (Maitah et al., 2014) and the same policies are applied by Russian Federation toward the sector of sugar industry (Smutka et al., 2014; Maitah et al., 2016; Maitah & Smutka, 2016).

Important agricultural products in the Syria include cereals, industrial crops (such as cotton, sugar beets, tobacco,vegetables and fruits (MAAR, 2010).

Potatoes together with rice and wheat belong among the three most important food crops in the world after rice and wheat in terms of human consumption (CBS–SYR. 2010).

With the increasing population pressure and growing environmental degradation, it becomes more and more important to increase productivity in sustainable ways. This requires access to appropriate agricultural inputs and technologies.

Mukul et al. (2013), found a significant differences in socio–economic characteristics of potato farmers and showed that majority of farmers have a medium farm size (0.34–1.0 acre), belong to young age category (20–35 years) having medium family size, illiterate, (1–10 years) farming experience, those characteristics is associated with inefficiency in potato production (Arif et al., 2012).

Khaldoon & Berndtsson (2012) investigated potato profitability in Uganda, they showed that education level is correlated positively with efficiency, indicating that public investments in education have a synergistic effects on outcomes in Uganda (Mugonola, 2007; FAO, 2008).

The relationship between farm size and production is a very controversy issue. Some author support the inverse relationship, while other authors hold that production relationship with farm area is non–linear and is U–shaped. However, this inverse relationship has disappeared, as a result of technology adjustment (Theisen, 2007).

Taking into account that, no previous studies concerning the efficiency of potato production, under Al–Ghab plain conditions were achieved in Syria, and the insufficiency of argue on inverse relationship hypothesis, it is necessary to investigate the factor that may affect the efficiency of potato production in the regioon (International Year of the Potato 2008).

This paper aimed to reveal some factors affecting the efficiency of potato production.

The specific objectives of the study are to:

- investigate technical efficiency of potato production in Al–Ghab region, under different farm size;
- disclose some factors that may affect the technical efficiency of farms in the region and;
- offer suggestions to increase the potato farming efficiency.

MATERIALS AND METHODS

The study took into consideration three major potato producing villages (Al–Jornaie, Al–Habit and Kurnaz) in Al–Ghab plain, which located in north west of Syria. This plain represents an area of 61,000 hectares of very fertile alluvial soils. The major crops cultivated in the area are wheat, sugar beet, cotton, potato as well as vegetables and legume crops.

In the countries surrounding the Mediterranean sea the potato is a crop of great significance. Due to favorable climatic conditions, it can be cultivated throughout the year where planting and harvesting dates depend on the specific area of cultivation. The Mediterranean region differs from Northern Europe not only in its environmental conditions but also in the different use of high technology and adaptation of potato cultivars. A great problem related to potato cultivation in the Mediterranean area is the availability of seed tubers at the right physiological stage (Frusciante & Ranalli, 1999).

Potato is planted twice per year, the early one in the spring (15 february–15 march) and harvested after 90–110 days of planting date, while the autumn planting is don on 15 August till 15 September.

The data were collected during July–October (2014) by a structured questionnaire designed in line with objectives of the study. Questionnaire consisted of main questions regarding potato farming practices and environment in which they grow potatoes.

Respondents selection (from each of village) was achieved by multistage sampling, based on their high participation in potato production. So, after villages selection, a list of potato producers was compiled from each village, where one hundred of potato farmers were selected using a systematic random samplings technique, so, the total selected respondents farmers accounted three hundreds (300). The respondents had to answer the following questions: the age of the farmer; the education level; the farming experience (years); the family size (number of family member's); the membership of agricultural organization; the farm size (1,000 sq meters Dunom); the seed type and the distance to farm land (kms).

The technical and allocative efficiency were estimated to point out the economic performance of potato farms in Al–Ghab region. Therefore, the Input–Oriented Data Envelopment Model (DEA) was used to determine technical and allocative efficiency by parametric and non–parametric techniques.

Technical efficiency (CRS), pure*technical efficiency* (VRS) and *scale efficiency* were determined to explore the causes of farms inefficiency. A farm with a technical efficiency between 0.90 > 1 was considered an efficient farm.

Taking into account that farmers are able to control their inputs rather than their outputs the input–oriented DEA model was used. Authors consider inputs relevant for potato production such as land, labor, fertilizers or seeds.

Technical efficiency, pure technical efficiency and scale efficiency were calculated to point out the overall status of potato productivity efficiency. In this paper we assume the same input for the three farms sizes.

The technical efficiency of a given decision making unit DMU, i.e. a farm, is the efficiency ratio equal to a weighted sum of outputs over a weighted sum of inputs. So, those weights for each DMU were calculated by solving an optimization non–linear problem. It maximizes the efficiency ratio for a DMU subjected to constraint so that the equivalent ratios for every unit in the set will be ≤ 1. In this manner, the efficiency rate will ranges from 0 to 1. solving the following mathematical programming problem will give the Optimal weights:

$$Max\ h_0 = \left[\frac{\sum_{r=1}^{S} u_r\, y_{ro}}{\sum_{i=1}^{m} v_i\, x_{io}}\right] \tag{1}$$

$$\frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{r=1}^{m} v_i\, x_{i0}} \tag{2}$$

(j = 1, 2, ...n); $u_r \geq 0$; $vi \geq 0$.
For (r = 1, 2, 3 ……s); (i = 1, 2, 3 …….m)
where h_0 is the ratio of outputs to inputs; u_r and v_i are the weights to be determined for the output *r* and input *i* respectively; yr_0 and the xi_0 are the observed output and input values for the *DMU* to be evaluated.

The aim is to obtain u_r and v_i weights that maximizes the efficiency ratio of *DMU*. To transform this problem into linear one, a new constraint *was introduced.* The denominator was set equal to 1 and the numerator is being maximized in this model. So, the input–oriented Charnes, Cooper, Rhodes (CCR) model will be:

$$Max\ h_0 = \sum_{r=1}^{s} u_r y_{i0} \tag{3}$$

Subject to:

$$\sum_{i=1}^{m} v_i\, x_{io} = 1 \tag{4}$$

$$\sum_{r=1}^{s} u_r\, y_{ri} - \sum_{i=1}^{m} v_i\, x_{ij} \ \leq 0\ (j = 1 \ldots \ldots . n) \tag{5}$$

$$u_r \geq\ \epsilon\ (r = 1 \ldots . . s),\quad v \geq \epsilon\ (i = 1 \ldots . . m)$$

ε is introduced in Eq. 2, which is an arbitrarily small positive number, to have a positive weight values for inputs and outputs.

To identify slack in inputs or output and reduces the number of restrictions of the DEA model, the following dual problem of the linear program was used:

$$Min\ h_0 = \theta_0 - \epsilon\left[\sum_{i=1} s_i^- + \sum_{r=1} s_r^+\right] \tag{6}$$

Subjected to:

$$\sum_{i=1}^{m} x_{ij}\, \lambda_j + s_i^- = \theta_0 x_{i0} (i = 1 \ldots \ldots . . m)$$

$$\sum_{r=1}^{m} y_{rj}\, \lambda_j + s_i^+ = y_{r0} (r = 1 \ldots \ldots . . s)$$

$$\lambda_j \geq 0 \quad (j = 1 \ldots \ldots , n).\ \ s_i^- \geq 0,\quad s_r^+ \geq 0$$

where θ_0 denotes the efficiency of DMU_0; y_{rj} is the amount of r_{th} outputs produced by DMU_0 using x_{ij} amount of i_{th} input; y_{rj} and x_{ij} are exogenous variables; λ_j represents the benchmarks for a specific DMU under evaluation; s_i^- and s_r^+ are the slack variables.

To identify if a farm (DMU) is operating in constant, decreasing or increasing returns to scale, the Banker, Charnes, Cooper (BCC) Model was used. Constant return to scale (CRS) linear programming problem was modified by adding the convexity constraint to Eq. 3, in order to calculate Variable.

So the BCC model become:

$$Min\ h_0 = \theta_0 - \varepsilon\left[\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_{r=1}^+\right] \quad (7)$$

$$\sum_{i=1}^{m} x_{ij}\,\lambda_j + s_i^- = \theta_0 x_{i0} (i = 1 \ldots \ldots, m)$$

$$\sum_{r=1}^{s} y_{rj}\,\lambda_j + s_r^+ = y_{ro} (r = 1 \ldots \ldots, s)$$

$$\sum \lambda_i \geq 1 \ (j = 1 \ldots \ldots . n). \ \ s_i^- \geq 0, \ \ s_r^+ \geq 0$$

Estimated scores of technical and pure technical efficiency were compared to determine if the inefficiency in a DMU is caused by inefficient agricultural practices or by the operating conditions. Banker et al. (1984) considers that the DMU is fully efficient, when it operates in the Most Productive Scale Size (MPSS). The use of the CRS specification will result into measures of technical efficiency which may be confused by scale efficiencies (SE), If all DMUs are not operating at the optimal scale. To calculate a TE without SE effects, the variable return to scale (VRS) specification was used.

$$TE_{\mathrm{CRS}} = PT_{\mathrm{EVRS}}.SE \quad (8)$$

where TE_{CRS} is technical efficiency of constant returns to scale: PTE_{VRS} is technical efficiency of variable returns to scale; *SE* is scale of efficiency; and

$$SE = TE_{\mathrm{CRS}} / PTE_{\mathrm{VRS}} \quad (9)$$

where $0 \leq SE \leq 1$ since $TE_{\mathrm{CRS}} \leq PTE_{\mathrm{VRS}}$.

If SE value is equals to 1, the firm is scale efficient. Whereas values less than 1 ($SE < 1$) reflect scale inefficiency, which could be either increasing ($NI < VR$) or decreasing ($NI = VR$) returns to scale. The sum of intensity variables (i.e. *) in the CCR model shows the increasing or decreasing return to scale:

$$\sum_{j=1}^{n} \lambda_j > 1 \text{ (increasing returns– to– scale).}$$

$$\sum_{j=1}^{n} \lambda_j < 1 \text{ (decreasing returns– to– scale).}$$

The sources of inefficiency for each farmer according to the input and output variables, and the target values of these variables were defined at farm level by means of the technical efficiency scores at constant returns to scale according to the following formulae:

$$X_{i0} = \theta_i^* x_{i0} - s_i^{-*} \quad (10)$$

$$Y_{r0} = y_{r0} - s_r^{+^*} \quad (11)$$

where X_{i0} is the target input i for 0th farmer; Y_{r0} is target output r for 0th farmer; x_{i0} is actual input i for 0th farmer; y_{r0} is actual output r for 0th farmer; θ_i^* is OTE score of 0^{th} farmer; $s_i^{-^*}$ is optimal input slacks; $s_r^{+^*}$ is optimal output slacks.

So, $\Delta x_{i0} = X_{i0} - x_{i0}$ is the quantity of input i to be reduced and $\Delta y_{r0} = Y_{r0} - y_{r0}$ represents the amount of output r to be increased, so that the inefficient farmer will be moved onto the efficient frontier. To make the farmer under evaluation efficient, the input reduction for the input i and output addition for the output r were calculated by $(\Delta x_{i0}/x_{i0}) \times 100$ and $(\Delta y_{r0}/y_{r0}) \times 100$ respectively.

Two–limit Tobit Regression Model was used to identify the determinants of farm Technical Efficiency. The empirical Tobit Model has been estimated as:

$$y_i^* = \beta_0 + \sum \beta_m \ X_{jm+\ \epsilon_i} \quad (12)$$

where y_i*is efficiency scores of farm; j is a vector of unknown parameters (increasing returns–to–scale); X_{jm} is vector of explanatory variables m (m = 1, 2... k) for farm j; ** = an error term that is independently and normally distributed with mean zero and common variance σ2.

The Tobit Regression Model can be written as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + U_i \quad (13)$$

where y_i* is efficiency scores of farm; j is a vector of unknown parameters (increasing returns–to–scale); Y is the Technical Efficiency Score (0 to 1); X_1 is the age of the farmer (years); X_2 is Education (years); X_3 is Farming Experience (years); X_4 is Experience Square; X_5 isMain occupation (1 = for farming and 0 = for other); X_6 is Family size (number of family member's); X_7 is Membership of agricultural organization (1 = if yes and 0 = if no); X_8 is Farm size (1,000 sq meters); X_9 is Farm size square; X_{10} is Household Assets Owned (value in 1,000 **Syrian Lira);** X_{11} is Seed Type (1 = improved seed verities and 0=otherwise); X_{12} is Distance to farm land (kms); U_i is the error term.

Slacks and targets were calculated to find out the ways for enhancing agricultural practices. In addition to the target values of inputs and outputs for inefficient farmers, the potential increase in outputs and potential reduction in inputs were determined, to improve the input–output activity and move inefficient farmers to the efficient frontier.

RESULTS AND DISCUSSION

In this section, results of the study are presented and discussed. Table 1 revealed that 90.7% of the respondents were men. This result mismatch with Galiè, A. (2013) who concluded that*: 'Women in the Syrian villages play substantial roles in farming and are increasingly involved in agricultural management, but they are generally overlooked or under–valued as farmers by both men and women, at the household and community levels. Men typically are considered to be the farmers' and women to be only their helpers'.*

Table 1 showed that 6.0% of the farmers are illiterate, while 94.0 have a formal study, however,52.7 have had secondary and 22.7 have higher education. Närman (1991) showed that:*'It is held that the skills transferred through the extension services for adoption by farmers would be more easily implemented by those who have acquired the ability in reading, writing and arithmetic. A consequence, if we accept this assumption, is that farmers without education may remain outside technical evolution in agriculture'*.

Results in Table 1 also shows that 82.3% of the farmers in Al–Ghab region had over ten years of experience in 'Diamond' potato production, which implies that the farmers were aware of processes involved in potato productions. Alabi et al. (2005), showed that farmers awareness increases efficiency and productivity in business.

Table 1 also revealed that 77% of the farmers had high family size ranging from seven to more than ten household members, the large family size implies availability of free family labor, thus, the reason for the lower cost of labor as compared to cost of seeds and fertilizers in the business.

Results also showed that 92.67% of farm size per farmer in the study area is less than 1 hectare (ha) which may increase unit costs and reduce benefits per ha. Also the hired labor was the smallest (28.0%) source of labor in the study area, so, family labor force would increase the profitability of potato production in Al–Ghab region.

Results in Table 1 shows that only 6.3% of the respondents were young (up to 25 years), which mean that the majority of potato farmers are aged adult, who have had several years of experience in 'Diamond' potato farming. This result agrees with the findings of Alabi et al. (2005) *'who observed that farmer's age has great influence on maize production in Kaduna state with younger farmers producing more than the older ones plausibly because of their flexibility to new ideas and risk'*.

Table 1. Socio–economic Characteristics of Diamond Potato Farmers in Al–Ghab region

Percentage	Frequency	Variable
Gender		
90.7	272.0	Male
9.3	28.0	Female
100	300	Total
Marital status		
88.3	265.0	Married
11.7	35.0	Single
100	300	Total
Educational level		
6.0	18	Illiterate
20.7	62	Primary
52.7	158	Secondary
15.0	45	Higher secondary
5.7	17	University
100.0	300	Total
Family size		
7.33	22	Up to 4
15.67	47	5–7
40.67	122	8–10
36.33	109	More than 10
100	300	Total

Table 1 (continued)

Age		
6.3	19	Up to 25
14.3	43	31–35
34.0	102	36–40
29.7	89	41–45
10.0	30	46–50
5.7	17	> 50
100.0	300	Total
Years of experience		
2.0	6	< 5
15.7	47	6–10
38.3	115	10–15
25.0	75	15–20
19.0	57	> 20
100.0	300	Total
		Farm size
40.67	122	Up to 0.4 ha
52.00	156	0.5–1 ha
7.33	22	more than 1ha
100	300	Total
		Labor
43.3	130	Family
28.0	84	Hiring
28. 7	86	family and hiring
100.0	300	Total
Primary occupation		
63.3	190	Farming
20.7	62	Public administration
16.0	48	Business
100.0	300	Total

The *technical inefficiency* could be considered the main source of inefficiencies of Syrian potato farming. As shown by the results from Table 2, around of 47% of potato production is lost due to technical inefficiency and the technical efficiency averaged only 53% of the potential output from a given mix of inputs.

Table 2. Distribution of farmers by their score of Technical Efficiency

Total Farms		Large Farms		Medium Farms		Small Farms		
%	Fre–quency	%	Fre–quency	%	Fre–quency	%	Fre–quency	Efficiency scale
15.58	50	6.3	6	30.4	35	10.0	9	0.10 < 0.30
39.84	121	33.7	32	47.0	54	38.9	35	0.30 < 0.60
24.9	73	32.6	31	16.5	19	25.6	23	0.60 < 0.90
19.67	56	27.4	26	6.1	7	25.6	23	0.90 < 1
100	300	100	95	100	115	100	90	Total
0.06		0.09	0.09	0.06		0.11		Minimum
1		1	1	1		1		Maximum
0.52950		0.5821		0.3924		0.554		Mean
0.28014		0.32546		0.16254		0.35243		Std. Deviation

Farm sizes affected the efficiency level, as it ranges between 0.11 to 1.00, 0.06 to 1.00 and 0.09 to 1.00 for small, medium and large farmers respectively. Small farms showed the highest mean of technical efficiency (0.55) as compared with medium (0.43) and large farms (0.45).

25.6% of small farms were technically efficient (0.90 > 1), however, this efficiency decreases to (6.1%) for medium size farmers at first, then it increases to (27.4%) for large size farmers. So the technical efficiency first decreases from small farms to medium farms and thereafter it increases for large farmers.

Most of farms(80.31%) were operated inefficient technically,as only 19.67% of them were technically efficient.

The averages of Pure efficiency were 86.6%, 84.3% and 80.0% for small, medium and large farms respectively.

The technical efficiency ranged between 0.40 to 1.00, 0.50 to 1.00 and 0.09 to 1.00 for small, medium and large farmers respectively. The overall technical efficiency under variable returns to scale varied between 0.33 to 1.00.

In addition 83.6% of all farmers were efficient technically under the variable returns to scale.

Scale efficiency *(SE)* equal to 1 means that the farm is operated at the *Most Productive Scale Size (MPSS)* which corresponds to constant returns to scale, whereas *SE < 1* means that the farm is inefficient technically because of the scale size (Table 3.)

Table 3. Distribution of farmers by their score of Pure Tech Efficiency

Total Farms		Large Farms		Medium Farms		Small Farms		
%	Fre–quency	%	Frequency	%	Fre–quency	%	Fre–quency	Efficiency scale
0	0	0.0	0	0.0	0	–	0	0.10 < 0.30
4.456	13	6.3	6	2.6	3	4.4	4	0.30 < 0.60
11.87	36	13.7	13	13.0	15	8.9	8	0.60 < 0.90
83.67	251	80.0	76	84.3	97	86.7	78	0.90 < 1
100	300	100	95	100	115	100	90	Total
0.33		0.09		0.5		0.4		Minimum
1		1		1		1		Maximum
0.836		0.800		0.843		0.866		Mean
0.11221		0.32546		0.16254		0.15243		Std. Deviation

The mean of SE were 55.4%, 47.2% and 43.1% for small, medium and large farms respectively (Table 4). The results showed an SE scores ranged from 0.11 to 1, 0.09 to 1 and 0.15 to 1 for Small medium and large farms respectively.

Only 24.0% of farms were operating at MPSS as they attained SE score equal to 1, so 76% of farms were operating with either increasing or decreasing returns to scale. this result suggests that scales is a major impediment for efficient potato farming in Al–Ghab region.

Table 5 showed that 14.3%, 10.7% and 75.0% of farms are operating under CRS, DRS and IRS respectively. So proper reallocation of the used resources is necessary to improve the efficiency. About 43 (14.3%) of farmers were working under MPSS, and 32 (10.2%) of farmers were working under decreasing returns to scale, while 225 (75.0%) of them farmers were working under increasing returns to scale. Therefore, farmers with decreasing return to scale should reduce their utilized resources to reduce the production unit costs, while farmers with increasing return to scale should increase their utilized resources to increase their production and achieve optimal scale.

Table 4. Distribution of potato farmers by their score of Scale Efficiency

Total Farms		Large Farms		Medium Farms		Small Farms		
%	Fre–quency	%	Fre–quency	%	Fre–quency	%	Fre–quency	Efficiency scale
19.0	57	24.2	23	22.6	26	8.9	8	0.10 < 0.30
44.7	134	36.8	35	60.0	69	33.3	30	0.30 < 0.60
12.3	37	5.3	5	10.4	12	22.2	20	0.60 < 0.90
24.0	72	33.7	32	7.0	8	35.6	32	0.90 < 1
100	300	100	95	100	115	100	90	Total
0.03		0.15		0.09		0.11		Minimum
1		1		1		1		Maximum
0.6541		0.4311		0.4721		0.5541		Mean
0.2358		0.1524		0.1754		0.2732		Std. Deviation

Table 5. Comparison of potato farmers by Various Returns to Scale

Total Farms		Large Farms		Medium Farms		Small Farms		
%	Fre–quency	%	Fre–quency	%	Fre–quency	%	Fre–quency	Scale Efficient Farms
14.3	43	21.1	20	13.9	16	7.8	7	Constant
10.7	32	13.7	13	12.2	14	5.6	5	Decreasing
75.0	225	65.3	62	73.9	85	86.7	78	Increasing
100	300	100	95	100	115	100	90	Total

So, to attain the level of efficient peers, the inefficient farmers should increase Chemical pesticides, number of irrigation and improved seeds by 18.7, 16.01 and 10.04% respectively, and decrease Labor by 24.5% and of Fertilizers by 14.1%.

Slack Output (Table 6) suggest that on average, inefficient farmers could increase their output by $ 40.47 US. by using the same inputs. The average of actual output $ 6,617 US per 1,000 sq.meters, could be increased with the same level of inputs. To reach the efficient frontier, inefficient farmers (DRS) could reduce labor by 24.51% ($258 US per 1,000 sq.meters) and fertilizer by 14.14% ($82 US per 1,000 sq.meters). Whereas, they could reduce chemicals costs by approximately $2 per 1,000 sq. Meters, irrigation by $18.6 US per 1,000 sq.meters and seed by $109.47 US per 1,000 sq.meters to reach the efficient frontier.

Table 6. Average actual and target output and input quantities for inefficient farmers

Percentage	Target	Slacks	Actual	Variables
0.61	1,427,074.3	8,676.75	1,418,397.58	Output
58.97	3.1	1.15	1.95	Cultivated area
–24.51	170,366.03	–55,322.17	225,688.20	Labor
–14.14	106,658.35	–17,577.1	124,235.45	Fertilizers
16.08	28,772.86	3,987.65	24,785.21	Irrigation
10.05	256,993.34	23,465.14	233,528.20	Seeds
18.72	2,772.39	437.18	2,335.21	Chemicals

Table 7. shows factors influencing Technical Efficiency, where F–test (0.0240) suggest that Tobit Regression Model is valid and it is distinct significant at 1% level and the pseudo R^2 is 27.8%.

Table 7. Factors Influencing Technical Efficiency (Tobit Regression Model)

Significance	Std. Err.	Coefficient	Variable
0.524	0.001233	–0.00022	Age
0.724	0.008214	0.00237	Education
0.091**	0.002088	0.008245	Experience
0.083**	6.50E–05	–0.00111	Experience Square
0.068**	0.010006	–0.0278	occupation
0.025*	0.002489	0.003144	Household size
0.076**	0.05871	0.0333102	membership
0.022*	0.0043452	–0.09872	Farm size
0.074**	0.00614	0.0065884	Farm size square
0.066**	0.03564	0.02244	Seed Type
0.175	0.01233	–0.0012	distance
0.35	0.00051	0.0000425	Household Assets
0.033	0.000323	0.350211	Constant
F(56, 212) = 1.75		Log Pseudo Likelihood = –11.228725	
Prob > F = 0.0240		Pseudo R^2 = 0.2780	

Note: *significant at 5%, ** significant at 1%.

Occupation, Membership, Farming Experience, Farm Size, Seed Type and Household Size have significant influences on technical efficiency. Farmer's age have a negative effect on technical efficiency of the farms, but the relationship is not significant.

Although no significant relationship were found between education and farm efficiency, the increase by one year of education increased the farm efficiency by 0.72%. A positive and significant (at 10% level) relationship was fond between farming experience and farm's technical efficiency. But, the coefficient of Experience Square is negative and significant (10%) which suggest an increase in technical efficiency, at first stage, with the increase in experience, thereafter in the second stage, the increase in experience would reduce the technical efficiency. This is because, farmers with more years of farming experience are aged people who are (generally speaking) more conserved towards modern farming technology.

The farm technical efficiency decreased by 2.7% with farmer's primary occupation, this may be attributed to the fact that farmers who have alternative income from employment, business or any others, are more able to finance their farming activities than those with only farming occupation.

Membership increased the technical efficiency level by 3.3% as compared their peer non–membership. The results showed a positive relationship (p = 5%) between household size and technical efficiency. This may be attributed to the increase in availabi

A negative relationship (p = 5%) was found between farm size and technical efficiency, this may be attributed to that small lands are more easy to control and manage as compared with medium and large one. However, the square of farm size showed a significant positive relation at 10% level, which mean that the efficiency decreases up to a certain point, thereafter it increases with increase of farm size.

The household assets have a positive impact on the technical efficiency, but this insignificant at p = 10%. A positive relationship was found between seed type and farm efficiency but insignificant at 5% level. Which mean that the use of improved varieties of seeds increased the level of farm efficiency.

The relationship between technical efficiency of farm and the distance from the farm to farmer's home was negative but insignificant at p = 10%. The increase in distance by one kilometer will decrease the farm technical efficiency by 1.2%. The farther the farm the greater cost of inputs and outputs transport, management, supervision, etc.

CONCLUSIONS

In this paper, economic analysis of potato production in Al–Ghab region, Hama–Syria, weas provided. The data collected from farmers by questionnaires were analyzed by using the Non–parametric Data Envelopment Analysis (DEA) to determine the technical efficiency of Syrian potato farms.

The main findings are that farmers obtain 47% of potential output from a mix of inputs. At the same time, they lose 53% of their production due to the technical inefficiency. Non–linear relationship was found between farm size and productivity efficiency, so the efficiency is reduced when moving from small to medium size and then raised with the raise in farm size. The highest net farm income per area and highest technical efficiency were shown at Large farms followed by small and medium farm size.

The Scale Inefficiencies (SIE) in Al–Ghab region amounted 53% which suggest that potato farming could be improved substantially.

The highest productivity were recorded in large farms followed by small and medium farms, this is due to technically efficient. So in addition to technical efficiency, the farm size is a major source of farming inefficiency. Therefore, medium farm should be integrated in such a way that eliminate this technical insufficiency.

The technical efficiency level was affected significantly by farmer's experience, occupation, household size, membership, farm size and seed type, as shown by the results from Tobit Regression. This could be taken into account by authorities when plans are proposed to improve farmer's skills by allocating more investment in farm research and extension programmers.

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