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Optimization model of peach production relevant to input energies – Yield function in Chaharmahal va Bakhtiari province, Iran

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ABSTRACT

The aim of this study was to determine the amount of input–output energy used in peach production and to develop an optimal model of production in Chaharmahal va Bakhtiari province, Iran. Data were collected from 100 producers by administering a questionnaire in face-to-face interviews. Farms were selected based on random sampling method.

Results revealed that the total energy of production is 47,951.52 MJ/ha and the highest share of energy consumption belongs to chemical fertilizers (35.37%). Consumption of direct energy was 47.4% while indirect energy was 52.6%. Also, Total energy consumption was divided into two groups; renewable and non-renewable (19.2% and 80.8% respectively). Energy use efficiency, Energy productivity, Specific energy and Net energy were calculated as 0.433, 0.228 (kg/MJ), 4.38 (MJ/kg) and −27,161.722 (MJ/ha), respectively. According to the negative sign for Net energy, if special strategy is used, energy dismiss will decrease and negative effect of some parameters could be omitted. In the present case the amount is indicating decimate of production energy. In addition, energy efficiency was not high enough.

Some of the input energies were applied to machinery, chemical fertilizer, water irrigation and electricity which had significant effect on increasing production and MPP (marginal physical productivity) was determined for variables. This parameter was positive for energy groups namely; machinery, diesel fuel, chemical fertilizer, water irrigation and electricity while it was negative for other kind of energy such as chemical pesticides and human labor. Finally, there is a need to pursue a new policy to force producers to undertake energy-efficient practices to establish sustainable production systems without disrupting the natural resources. In addition, extension activities are needed to improve the efficiency of energy consumption and to sustain the natural resources.

1. Introduction

Peach (Prunuspersica) is a member of the Rosaceae family and it stemmed from China. This name (Prunu persica) is originated to Persia (Iran) as the reputed country of origin [1,2]. Seven million ton peaches are produced annually all around the world. Iran with production of 600,000 tons has 8% of total global production. Iran was the 6th producer with 35,000 ha cultivation land area and 390,000 tons of production in 2012 [3].

Chaharmahal va Bakhtiari is one of the provinces which is the large producer of peach in Iran. In addition, peach cultivation land area and production in this province are 4448 ha and 38,597 tons (10,942 kg/ha) [4].

Energy plays an important role in social and economic development of a country. The level of using energy enhances with increasing agricultural and industrial activities. Formulization of an energy model will support in assigning resources of available renewable energy (solar, wind, bio-energy and small hydropower) in future for countries such as India, Nepal, Pakistan, Sri Lanka, Myanmar, Bangladesh, etc. Over the past decade, several new concepts of energy scheming and handling such as energy conservation via improved technologies, waste recycling, decentralized planning, integrated energy planning, the introduction of renewable energy sources and energy forecasts have appeared. Scientists tried to understand and explore emerging issues related to the modeling. Various models such as energy planning, energy supply-

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Nomenclature

n	required sample size
N	number of holdings in target population
s	standard deviation
d	acceptable error (permissible error was chosen as 5%)
t	confidence limit (1.96 in the case of 95% reliability)
Y_i	yield level of the ith farmer
X_1	labor energy
X_2	machinery energy
X_3	diesel fuel energy
X_4	chemicals energy
X_5	chemical fertilizer energy
X_6	farmyard manure energy
X_7	water irrigation energy
X_8	electrical energy
e_i	error
α_i	coefficients of the exogenous variables
β_i	coefficients of the exogenous variables
γ_i	coefficients of the exogenous variables
DE	direct energy
IDE	indirect energy
RE	renewable energy
NRE	non-renewable energy
MPP_{xj}	marginal physical productivity of jth input
α_j	regression coefficient of jth input
GM(Y)	geometric mean of yield
GM(X_j)	geometric mean of jth input energy

demand models, prediction models, models of renewable energy, the emission reduction and optimization models were investigated and presented [5].

Applicable energies for agriculture are parted into four main groups: renewable, non-renewable, direct and indirect energies. NRE (Non-renewable energy) includes chemical pesticides, chemical fertilizers, machinery, diesel fuel and electricity whilst RE (renewable energy) refers to farmyard manure, human labor, and water irrigation. DE (Direct energy) includes diesel fuel, electricity, human labor and water irrigation, whilst IDE (indirect energy) refers to machinery, farmyard manure, chemical pesticides and fertilizers which utilized for agricultural productions [6]. Analysis of relationship between input and output energy is utilized for assessing efficiency and impact on environment of production systems. Aforementioned analysis will qualify efficient way of using energies. Different researches had analyzed the energy sector for different agricultural productions; alfalfa, apples, barley, canola, kiwifruit, potato, soybeans, strawberries and tomatoes (in Iran) [7–13], almonds, apple, apricot, barley, corn, grapes, lemon, oats, olives, orange, pear, peach, plum, rye, sugar beets, sunflowers and wheat (in Italy) [14], maize, sorghum and wheat (in the United States) [15, 16], apricot, beet, cotton, canola, citrus, cherries, pomegranate, sweet cherries, tomato and vegetable crops (in Turkey) [17–26], cotton, potato and sunflower (in Greece) [27–29], rice (in Malaysia) [30], soybean (in India) [31], cotton and wheat (in Punjab) [32,33], cereals, sugar beet and potatoes (in Denmark) [34], wheat (in New Zealand) [35].

In this study, the main target was to calculate the applicable energy efficiency per hectare and analyze the sensibility of energy inputs to find relation between energy inputs and output by applying math models on the peach farms in Chaharmahal va Bakhtiari province, Iran.

Generally, two approaches are competitive in measuring productivity of the stochastic frontier model (parametric and non-parametric) by using DEA (data envelopment analysis). Recently, the production efficiency in cucumber greenhouse has determined by using DEA [13]. It is worth mentioning that no prior assumptions are required on the underlying functional relationship between inputs and outputs as a non-parametric method [36].

2. Material and methods

This research was done in Chaharmahal va Bakhtiari province as a main agricultural producer in Iran (Fig. 1). This province is located in the south-west of Iran within 31°4′ – 33°47′ north latitude and

Fig. 1. Geographic location of Chaharmahal va Bakhtiari in Iran [4].

49°30′ – 51°31′ east longitude. Additionally, total area of Chaharmahal va Bakhtiari province is 1,633,200 ha which is 1% of total area of Iran and farming land is 185,141 ha.

During August and September 2013, data of this research were collected from the 100 peach farms from questionnaire which were filled from face-to-face interviews. The sample size of farms in the research area was estimated by using one of the stratified random sampling techniques which is called Cochran method [37]. The required sample size is presented by Equation (1).

$$n = \frac{N(s \times t)^2}{(N-1)d^2 + (s \times t)^2} \quad (1)$$

The amount of t is considered 1.96 at 95% reliability and d the acceptable error is calculated by using Equation (2);