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# Assessing GHG emissions, and energy and economic analysis of cotton production in the Golestan province

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**Introduction:** Golestan province is one of Northern provinces in Iran. The area under cultivation of agricultural products in this province is 724.697 hectares, of which about 694.618 hectares are used for farm products (AJMDC, 2011). Cotton as one of oilseed is a potential feedstock for biodiesel production (Ahmad *et al.*, 2011). In the study of energy consumption and greenhouse gas emissions for cotton production in Alborz province, results showed that the total energy input was 31.237 MJ $ha^{-1}$. Energy efficiency and energy productivity were 1.85 and 0.11, respectively, and greenhouse gas emissions of cotton production in Alborz province were 1195.25 kg $CO_2$eq $ha^{-1}$ (Pishgar-Komleh *et al.*, 2012). Another study on energy analysis, greenhouse gas emissions and economic analysis of agricultural production was performed in Northern Iran (AghaAlikhani *et al.*, 2013; Royan *et al.*, 2012; Pishgar-Komleh *et al.*, 2011; Mohammadi *et al.*, 2010; Taheri-Garavand *et al.*, 2010). The aims of this study were to determine the energy flow, greenhouse gas emissions and economic analysis of cotton production in the Golestan province and also to determine the effect of energy inputs on cotton yield.

**Materials and methods:** This research was conducted during 2011-2012 in three areas including Gorgan, Aq'qala and Gonbad in the Golestan province. The primary data were collected from the rice producers through a field survey with the help of a structured questionnaire. The number of subjects were studied by the Cochran formula (Snedecor and Cochran, 1980). Accordingly, 43 cotton producers were determined. In this study, eight energy inputs including seed, labor, machinery, diesel fuel, chemical fertilizers, chemicals, water for irrigation and farmyard manure for cotton production system were considered as independent variables. The outputs of the system including lint and seed were considered as dependent variable. Energy indices including energy efficiency, energy productivity, specific energy and net energy were calculated. In this study, the effect of energy inputs on yield was estimated using the Cobb-Douglas function. In order to determine the sensitivity of energy inputs in the production of cotton in the Golestan province, the marginal physical productivity method was applied. Greenhouse gas emissions, inputs of agricultural machinery, fuel, chemical fertilizers, chemicals and farmyard manure in cotton production in the Golestan province were calculated by the coefficients of each of these inputs. For economic evaluation of cotton production in the Golestan province, the variable costs, fixed and total production per unit area were considered. Economic indices of total production value, gross income, net income, economic productivity and benefit to cost ratio were estimated. Data analysis was performed using JMP8 software.

**Results and Discussion:** Cotton yield in the Golestan province was about 2650 kg $ha^{-1}$. Average cotton yield in the Alborz province was reported to be 3430 kg $ha^{-1}$ (Pishgar-Komleh *et al.*, 2012). In this study, diesel fuel had the highest energy consumer among other inputs like the other studies that have been done on energy crop production in Iran. Labor energy input with energy consumption of 2413 MJ $ha^{-1}$, is known to be the fourth high-energy input in cotton production in the Golestan province. However, in many studies in Iran, this input was accounted to be less than one percent of the energy consumption in the production of agricultural products (Saeedi *et al.*, 2013; Khoshnevisan *et al.*, 2013; Mobtaker *et al.*, 2012; Mobtaker *et al.*, 2010). Chemical energy input with 1036 MJ $ha^{-1}$, was allocated as 3.6% of energy consumption in the cotton production in the region. Seed energy input was the lowest energy among the other inputs in cotton production in the Golestan province. The results revealed that the total energy inputs for cotton production in the Golestan province was 28.898 MJ $ha^{-1}$. The average energy efficiency for cotton production in the Golestan province was obtained to be 1.58. Energy productivity for cotton production in the Golestan province was

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calculated to be 0.092. From the results of Cobb-Douglas function to determine the relationship between energy input and yield of cotton in Golestan province, the effects of human labor, diesel fuel, water for irrigation, chemical fertilizers and farmyard manure inputs on the yield were positive, and the effects of agriculture machinery and chemicals inputs on cotton yield were negative. Greenhouse gas emission from diesel fuel input hadthe highest value of 646.23 kg $CO_2$eq $ha^{-1}$ with a 45.2 percent share. Farmyard manure with 23.5 percent of greenhouse emissions was identified as the second largest input in greenhouse gas emissions in cotton production. Variable costs, fixed and total cotton production in the Golestan province were calculated to be 3042429, 851880 and 3894309 Toman $ha^{-1}$, respectively. Benefit to cost ratio for the cotton production in the Golestan province was calculated as 1.16.

**Conclusions:** The results of this study showed that the energy efficiency for cotton production in the Golestan province was less than the energy efficiency for cotton production in the Alborz province, Hatay province of Turkey, and canola, soybean and sunflower production in the Golestan province. Also, the energy efficiency of cotton production was less than that of cotton production in Antalya Turkey and canola in the Mazandaran province. The highest share of energy consumption and greenhouse gas emissions belonged to diesel fuel with the share of 45.6 and 45.2 percent, respectively. However, this input accounted for 2.7 percent of variable costs.

**Keywords:** Cobb-douglas, Cotton, Energy, Greenhouse gas