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Research Article

Determination of Greenhouse Gas Emissions (GHG) in the Production of Different Aromatic Plants in Turkey

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Abstract

The release of greenhouse gas emissions is a source of great concern for Turkey. However, agriculture is among the key actors in terms of environmental impact in Turkey, as agriculture not only consumes energy but it also produces it and it can have both positive and negative effects on the environment. This study was conducted in order to determine GHG emissions for four different medical, aromatic and pleasure plants production (guar, lavender, sesame and tobacco) in the different provinces of Turkey. For this purpose, the first data was collected from references. The results indicated that total GHG emissions for four different aromatic plants production (guar, lavender, sesame and tobacco) production were computed as 1488.50 $kgCO_{2\text{-}eq}ha^{-1}$, 494.81 $kgCO_{2\text{-}eq}ha^{-1}$, 907.13 $kgCO_{2\text{-}eq}ha^{-1}$, 6604.58 $kgCO_{2\text{-}eq}ha^{-1}$ respectively. The GHG ratios were computed as 0.65 $kgCO_{2\text{-}eq}kg^{-1}$, 0.10 $kgCO_{2\text{-}eq}kg^{-1}$, 1.88 $kgCO_{2\text{-}eq}kg^{-1}$, 6.29 $kgCO_{2\text{-}eq}kg^{-1}$ respectively.

Key words: GHG emissions, GHG ratio, aromatic plants, Turkey.

Türkiye'de Farklı Aromatik Bitkilerin Üretilmesinde Sera Gazı Emisyonlarının (GHG) Belirlenmesi

Özet

Sera gazı emisyonlarının salınması, Türkiye için büyük bir endişe kaynağıdır. Ancak, sadece enerji tüketmekle kalmayıp aynı zamanda çevre üzerinde hem olumlu hem de olumsuz etkileri olabileceği için Türkiye'de tarım çevresel etkilerin en önemli aktörleri arasında yer almaktadır. Bu çalışma, Türkiye'nin farklı illerinde dört farklı tıbbi, aromatik ve keyif bitkisinin (guar, lavanta, susam ve tütün) üretimi sırasında oluşan sera gazı emisyonlarının belirlenmesi amacıyla yapılmıştır. Bu amaçla ilk veriler referanslardan toplanmıştır. Sonuçta, dört farklı aromatik bitkinin (guar, lavanta, susam ve tütün) üretimi sırasında oluşan toplam sera gazı emisyonları sırasıyla 1488.50 $kgCO_{2\text{-}eş}ha^{-1}$, 494.81 $kgCO_{2\text{-}eş}ha^{-1}$, 907.13 $kgCO_{2\text{-}eş}ha^{-1}$ ve 6604.58 $kgCO_{2\text{-}eş}ha^{-1}$ olarak, GHG oranları ise sırasıyla 0.65 $kgCO_{2\text{-}eş}kg^{-1}$, 0.10 $kgCO_{2\text{-}eş}kg^{-1}$, 1.88 $kgCO_{2\text{-}eş}kg^{-1}$ ve 6.29 $kgCO_{2\text{-}eş}kg^{-1}$ olarak hesaplanmıştır.

Anahtar kelimeler: GHG emisyonları, GHG oranı, aromatik bitkiler, Türkiye.

Introduction

Emission of a greenhouse gas (GHG) is something that both absorbs and emits radiation in atmosphere within a thermal infrared range (Nabavi-Pelesaraei et al., 2016). The GHG emissions are divided into two categories: namely anthropogenic and natural sources. Agricultural activities contribute directly to anthropogenic GHG emissions that their sources vary greatly, such as machinery, diesel fuel, fertilizers, biocides and electricity to name a few.

The most important direct GHG emissions are caused by chemical fertilizer use, and out of all GHG emissions, they represent around 20% and 30%, including smaller and larger farms (Lal, 2004).

A great number of practices have been examined with the purpose of decreasing the annual GHG release. These practises in question include crop nutrition, precision farming practices, tillage improvement, land grazing, livestock and manure management. Having a limited amount of energy resources as well as the great level of dependence on fossil fuels by agriculture have forced researchers to seek means of energy use efficiency in different crops and in different soils. Increasing the efficiency when using energy inputs will contribute for lower GHG emissions and environmental footprints, and consequently, food production systems will become more sustainable (Houshyar et al., 2015).

In 2017 (TUIK, 2018), agricultural activities were responsible for emissions of 56.56 Mt $CO_{2\text{-eq}}$ or 11.40% of total greenhouse gas emissions in Turkey. Agricultural activities come third after the energy and industrial sectors. CH_4, N_2O, and CO_2 were the primary greenhouse gases emitted by agricultural activities. 77.6% of N_2O emissions, 55.5% of CH_4 emissions and 0.3% of CO_2 emissions were caused by agricultural activities.

Several studies on determination of GHG emission have been concentrated generally on worldwide production of crops such as guar (Gresta et al., 2014), sesame (Sadiq et al., 2016), tobacco (Pardis and Devakumar, 2014; Tongwane et al., 2016), other fruits and vegetables (Garnett, 2006; Vetter et al., 2017) etc.

The aims of this study were to computed total GHG emissions and the GHG ratios of four different aromatic plants production (guar, lavender, sesame and tobacco) in the different locations (Table 1) of Turkey.

Table 1. References benefited for agricultural inputs and outputs of four different aromatic plants production

Plants	Location	References
Guar	Bingöl	Gökdoğan et al., 2017
Lavender	Isparta	Gökdoğan, 2016
Sesame	Şanlıurfa	Baran and Gökdoğan, 2017
Tobacco	Adıyaman	Baran and Gökdoğan, 2015

Material and Methods

This study is made up of agricultural inputs and outputs of references in Table 1.

The GHG emissions (kg $CO_{2\text{-eq}}$ ha^{-1}) associated with the inputs to growing 1 ha of aromatic plants were computed as following (adapted Hughes et al., 2011).

$$GHG_{ha} = \sum_{i=1}^{n} R(i) \, x \, EF(i) \qquad (1)$$

∑ where *R*(*i*) is the application rate of input *i* ($unit_{input}$ ha^{-1}) and EF(*i*) is the GHG emission coefficient of input *i* (kg $CO_{2\text{-eq}}$ $unit_{input}^{-1}$). Table 2 lists GHG emission coefficients of agricultural inputs.

Moreover, an index is defined to evaluate the amount of emitted kg $CO_{2\text{-eq}}$ per kg yield as following (adapted Khoshnevisan et al., 2014 and Housyar et al., 2015).

$$I_{GHG} = \frac{GHG_{ha}}{Y} \qquad (2)$$

Where I_{GHG} is GHG ratio and Y is the yield as kg per ha.

Table 2. Greenhouse gas (GHG) emission coefficients of agricultural inputs

Inputs	Unit	GHG coefficient (kg $CO_{2\text{-eq}}$ $Unit^{-1}$)	References
Human labour	h	0.700	Nguyen and Hermansen, 2012
Machinery	MJ	0.071	Pisghar-Komleh et al., 2012
Nitrogen (N)	kg	4.570	BioGrace-II, 2015
Phosphate (P_2O_5)	kg	1.180	BioGrace-II, 2015
Potassium (K_2O)	kg	0.640	BioGrace-II, 2015
Pesticides	kg	13.900	BioGrace-II, 2015
Diesel fuel	L	2.760	Clark et al., 2016
Water of irrigation	m^3	0.170	Lal, 2004
Sulphur	kg	0.370	Maraseni et al., 2010
Seed	kg	7.630	Clark et al., 2016

Results and Discussion

GHG emissions

Guar production

The results of GHG emission of guar production for Bingöl Province in Turkey are shown in Table 3. The total GHG emissions were computed as 1488.50 kg $CO_{2\text{-eq}}$ ha^{-1}. In similar a study, Gresta et al. (2014) computed the total GHG emission of guar production in southern Italy was about 2751.40 kg $CO_{2\text{-eq}}$ ha^{-1} and 2905.50 kg $CO_{2\text{-eq}}$ ha^{-1}.

The distribution of different inputs in total GHG emissions is illustrated in Figure 1. The results showed that the share of human labour in total GHG emissions was the highest (32.25%), machinery (17.66%) and diesel fuel (15.89%) held the second and third ranks. So, better agricultural management in terms of human labour can lead to guar production with lower GHG emissions in location.

Table 3. Greenhouse gas emissions of inputs in guar production

Inputs	Unit	Input used per area (Unit ha^{-1})	GHG Emissions (kg $CO_{2\text{-eq}}$ ha^{-1})
Human labour	h	685.71	480.00
Machinery	MJ	3702.67	262.89
Nitrogen (N)	kg	36.91	168.68
Phospate (P_2O_5)	kg	39.61	46.74
Potassium (K_2O)	kg	17.00	10.88
Diesel fuel	L	85.71	236.56
Water of irrigation	m^3	316.80	53.86
Seed	kg	30.00	228.90
		Total GHG Emission	1488.50

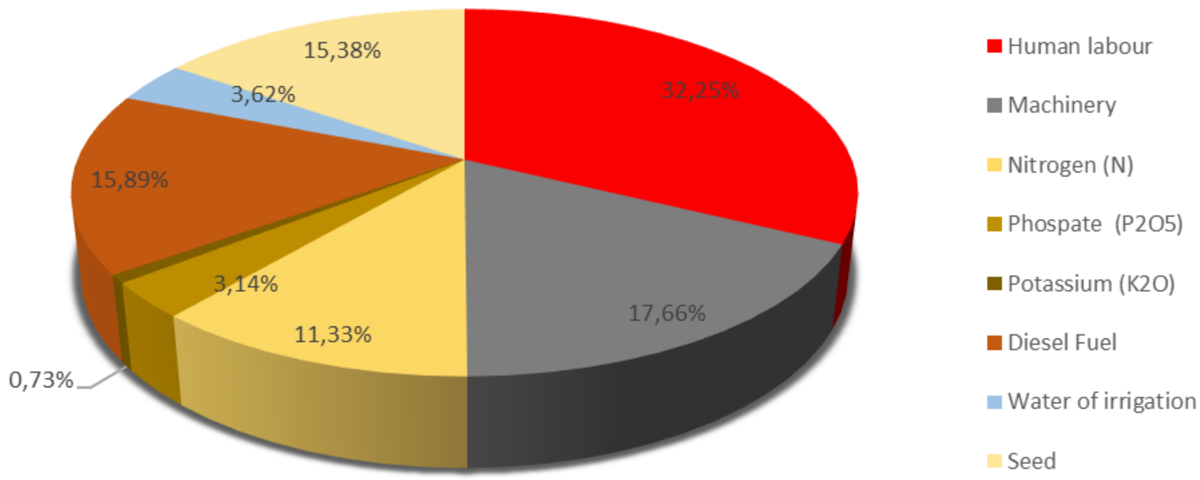

Figure 1. The distribution of different inputs in total GHG emission of guar production

Lavender production

The results of GHG emission of lavender production for Isparta Province in Turkey are shown in Table 4. The total GHG emissions were computed as 494.81 kg $CO_{2\text{-eq}}$ ha^{-1}.

The distribution of different inputs in total GHG emissions is illustrated in Figure 2. The results showed that the share of nitrogen fertilizer in total GHG emissions was the highest (44.24%), diesel fuel (20.92%) and human labour (13.68%) held the second and third ranks. So, better agricultural management in terms of nitrogen fertilizer can lead to lavender production with lower GHG emissions in location.

Sesame production

The results of GHG emission of melon production for Şanlıurfa Province in Turkey are shown in Table 5. The total GHG emissions were computed as 907.13 kg $CO_{2\text{-eq}}$ ha^{-1}. In similar a study, Sadiq et al. (2016) computed the total GHG emission of sesame production in Jigawa State of Nigeria was about 40.57 kg $CO_{2\text{-eq}}$ ha^{-1} (efficient farmers) and 56.50 kg $CO_{2\text{-eq}}$ ha^{-1} (inefficient farmers).

The distribution of different inputs in total GHG emissions is illustrated in Figure 3. The results showed that the share of nitrogen fertilizer in total

GHG emissions was the highest (33.25%), human labour (19.21%) and phosphate fertilizer (13.66%) held the second and third ranks. So, better agricultural management in terms of nitrogen fertilizer can lead to sesame production with lower GHG emissions in location.

Table 4. Greenhouse gas emissions of inputs in lavender production

Inputs	Unit	Input used per area (Unit ha^{-1})	GHG Emissions (kg CO_{2-eq} ha^{-1})
Human labour	h	96.73	67.71
Machinery	MJ	615.60	43.71
Nitrogen (N)	kg	47.90	218.90
Phospate (P_2O_5)	kg	28.50	33.63
Potassium (K_2O)	kg	17.00	10.88
Sulphur	kg	15.60	5.77
Pesticides	kg	0.77	10.70
Diesel fuel	L	37.50	103.50
		Total GHG Emission	494.81

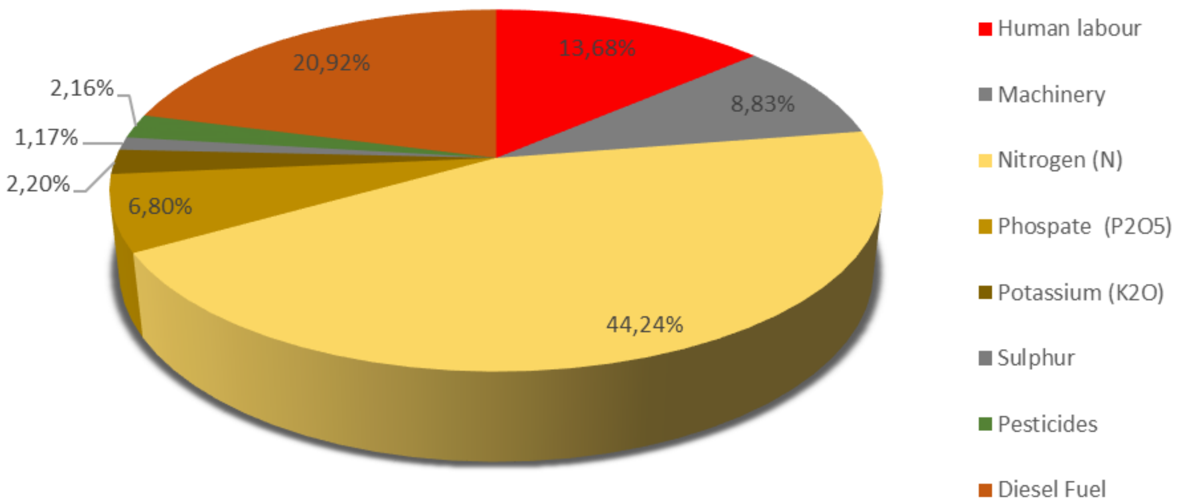

Figure 2. The distribution of different inputs in total GHG emission of lavender production

Table 5. Greenhouse gas emissions of inputs in sesame production

Inputs	Unit	Input used per area (Unit ha^{-1})	GHG Emissions (kg CO_{2-eq} ha^{-1})
Human labour	h	248.90	174.23
Machinery	MJ	1289.52	91.56
Nitrogen (N)	kg	66.00	301.62
Phospate (P_2O_5)	kg	105.00	123.90
Potassium (K_2O)	kg	50.00	32.00
Sulphur	kg	10.00	3.70
Pesticides	kg	0.50	6.95
Diesel fuel	L	37.00	102.12
Water of irrigation	m^3	216.00	36.72
Seed	kg	4.50	34.34
		Total GHG Emission	907.13

Tobacco production

The results of GHG emission of tobacco production for Adıyaman Province in Turkey are shown in Table 6. The total GHG emissions were computed as 6604.58 kg CO_{2-eq} ha^{-1}. In similar studies, Pardis and Devakumar (2014) computed the total GHG emission of tobacco production in Southern India was about 200 kg CO_{2-eq} ha^{-1}, Tongwane et al. (2016) computed the total GHG emission of tobacco production in Southern Africa was about 360 kg CO_{2-eq} ha^{-1}.

The distribution of different inputs in total GHG emissions is illustrated in Figure 4. The results showed that the share of human labour in total

GHG emissions was the highest (67.62%), water of irrigation (11.55%) and nitrogen fertilizer (10.17%) held the second and third ranks. So, better agricultural management in terms of human labour can lead to tobacco production with lower GHG emissions in location.

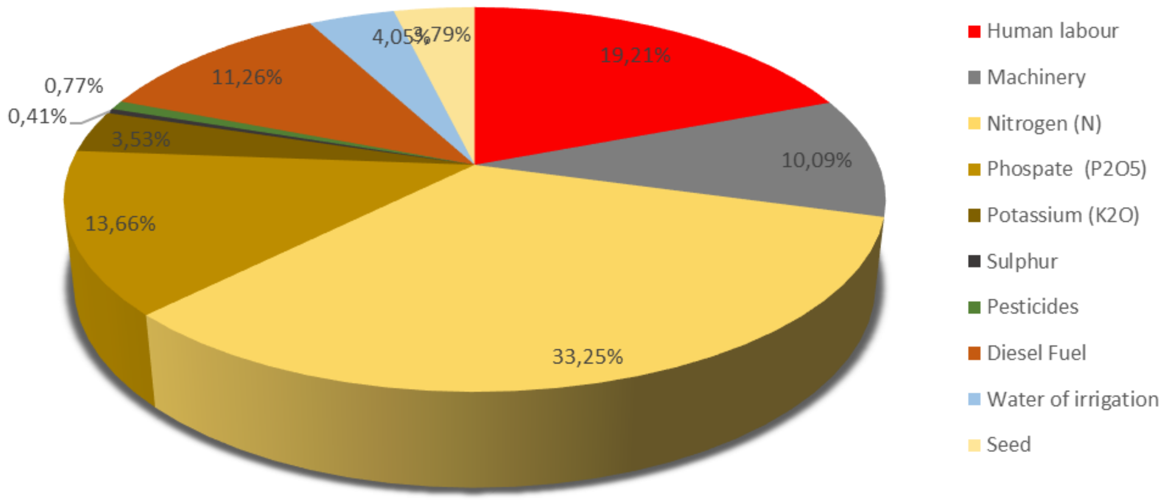

Figure 3. The distribution of different inputs in total GHG emission of sesame production

Table 6. Greenhouse gas emissions of inputs in tobacco production

Inputs	Unit	Input used per area (Unit ha^{-1})	GHG Emissions (kg CO_{2-eq} ha^{-1})
Human labour	h	6379.60	4465.72
Machinery	MJ	3633.34	257.97
Nitrogen (N)	kg	147.00	671.79
Phospate (P_2O_5)	kg	73.50	86.73
Potassium (K_2O)	kg	189.00	120.96
Pesticides	kg	6.72	93.41
Diesel fuel	L	52.50	144.90
Water of irrigation	m^3	4488.75	763.09
Seed	kg	0.002	0.02
		Total GHG Emission	6604.58

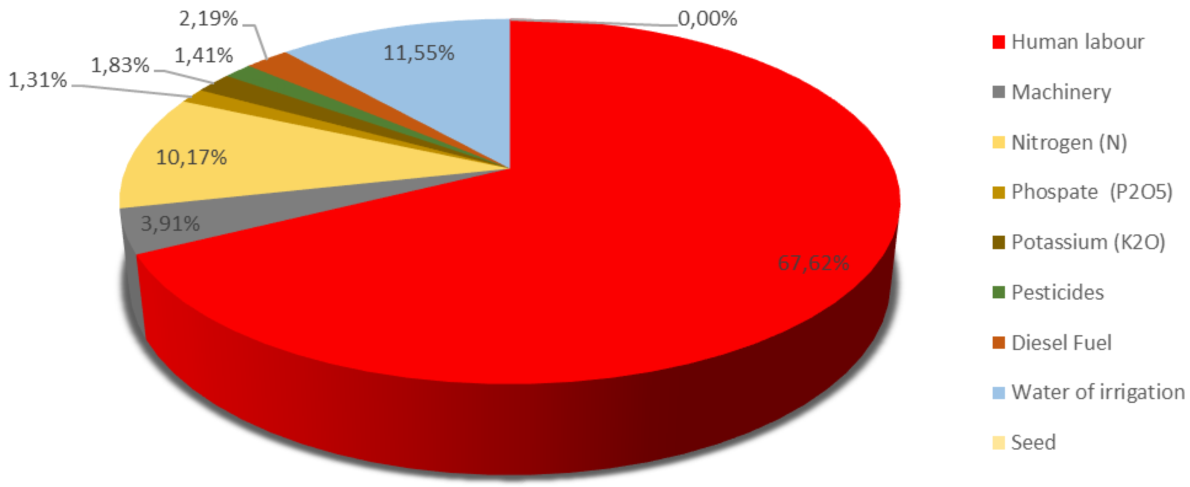

Figure 4. The distribution of different inputs in total GHG emission of tobacco production

Comparison and GHG ratios

The results of comparison of different aromatic plants productions in Turkey are shown Table 7 and Figure 5. The total GHG emissions were computed between 494.81 – 6604.58 kg CO_{2-eq} ha^{-1}. The lowest value was determined for lavender production and the highest value determined for tobacco production.

The GHG ratios were computed between 0.10 – 6.29 kg CO_{2-eq} kg^{-1}. The lowest value was determined for lavender production and the highest value determined for tobacco production.

Table 7. Total GHG emissions, yields and GHG ratios of diffirent aromatic plants productions in Turkey

Plants	GHG Emissions (kg CO_{2-eq} ha^{-1})	Yield (kg ha^{-1})	GHG Ratio (kg CO_{2-eq} kg^{-1})
Guar	1488.50	2278	0.65
Lavender	494.81	4725	0.10
Sesame	907.13	482	1.88
Tobacco	6604.58	1050	6.29

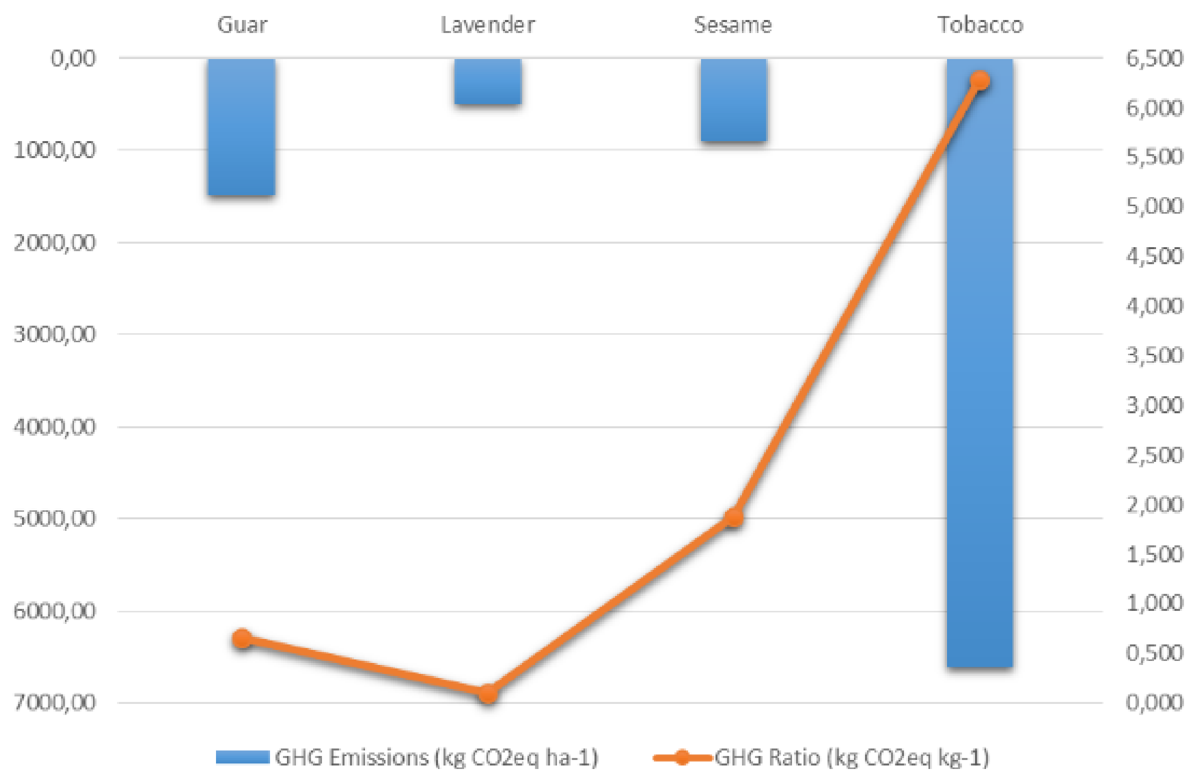

Figure 5. Total GHG emission and GHG ratio of different aromatic plants production in Turkey

Conclusions

Based on the results of this study, following conclusions are drawn:

- The results of total GHG emission indicated that the lowest value (494.81 kg CO_{2-eq} ha^{-1}) was determined for lavender production and the highest value (6604.58 kg CO_{2-eq} ha^{-1}) determined for tobacco production.

- The results of the distribution of different inputs in total GHG emissions showed that the share of chemical fertilizer was the highest (53.24%, 50.44%, respectively) for lavender and sesame production.

- The results of the distribution of different inputs in total GHG emissions showed that the share of human labour was the highest (67.62%, 32.25%, respectively) for tobacco and guar production.

- The results of GHG ratio indicated that the lowest value (0.10 kg CO_{2-eq} kg^{-1}) was determined for lavender production and the highest value (6.29 kg CO_{2-eq} kg^{-1}) determined for tobacco production.

- Reducing chemical fertilizer consumption (mainly nitrogen) and human labour are the most important ways in different aromatic plants production in the research regions in Turkey. For this purpose, applying soil analysis to specify the soil fertilizer needs (to decrease high chemical fertilizer causing GHG emissions) and human labour efficiency are recommended.

- GHG emissions should be determined in production of all agricultural products in Turkey.

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