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Assessment of greenhouse gas emission from yard-long-bean cultivation by farmers in Pathum Thani province

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Abstract

This research on greenhouse gas emission from yard-long-bean (*Vigna unguiculata* subsp. *sesquipedalis* (L.) Verdcourt) cultivation aims 1) to study the methods and activities of yard-long-bean cultivation in Nong-Suea district and 2) to calculate greenhouse gases (GHG) generated from all activities of yard-long- bean cultivation throughout its life cycle. Random sampling of 10 yard-long-bean farmers provided the basis for analysis that covers all activities of yard-long-bean cultivation, beginning from sourcing raw materials, planting, care, harvest, transportation, consumption and waste disposal. The study found that significant activities relating to GHG emissions were soil preparation, transplanting of sprouts, watering, fertilizer application, pole supports, bag covering, transportation, consumption and waste disposal. The average amount of greenhouse gases calculated from all activities was 743.06 $kgCO_2eq/ha$. The result shows no significant differences in GHG emission between the farmers at the p-value of 0.469, while each activity generated greenhouse gases with significant differences at the p-value of 0.0009. Additionally, the 11-12 months periods of caring for the yard-long beans generated the highest emissions of GHG due to applications of fertilizers and chemicals as well as watering activities.

Keywords: greenhouse gases, yard-long-bean cultivation, Nong-Suea district

1. Introduction

Today, human beings continuously produce greenhouse gases (GHG) from various activities such as energy consumption, agriculture, industrial development and expansion, transportation, deforestation, and other exhaustion of natural resources. These activities are important contributors to climate change, which has and will continue to have a wide range of negative impacts on ecological systems. The work to reduce greenhouse gas emission is the responsibility of everyone whether they are producers in the industrial or agricultural sector, worker in the service sector, or as a consumer of commercial products. Consumer avoidance of goods or services that have high GHG emissions allows the individual an opportunity to be proactive in the management of GHG emissions. This principle is based on the theory of market demand. As market demand for low GHG products increase, the producer will, likely, focus on methodologies that reduce the production of carbon footprint. Carbon footprint is a measurement of GHG such as CO_2, CH_4, and N_2O, emissions released throughout the product's life cycle. This includes the emissions associated with sourcing materials, planting, harvesting, transportation, and disposal. A labeling system has been developed to illustrate the carbon footprint of a given product as well as to inform and educate consumers about the different environmental impacts of products. This will lead to creating an increase in demand for more environmentally conscious products [1].

With this in mind, the researchers examined the carbon footprint associated with cultivating yard-long-beans. This research assessed different life cycle stages in the cultivation process, including soil preparation, planting, caring, harvesting and transportation. It is common knowledge that greenhouse gases like carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have been accumulating in the atmosphere at high density [2]. These gases can occur naturally in the environment come from anthropogenic sources such as transportation, industries, oil production, deforestation and agriculture. In agriculture, gourd growing releases a large volume of carbon dioxide, methane and nitrous oxide. Therefore, this research was done to study the environmental impacts of agricultural produce and products in relation to assessment of carbon footprint.

2. Objective

1. To study the life cycle of yard-long-beans in Nong-Suea District, Pathum Thani Province, Thailand.

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2. To assess the emission of greenhouse gases from yard-long-bean cultivation in Nong-Suea District, Pathum Thani Province, Thailand.

3. Methods

This research on the views and practices of farmers who grow yard-long-beans in Nong-Suea District, Pathum Thani Province, involves population samples, research tools, data collection and data analysis.

3.1 Target population

The target population for this research was yard-long-bean farmers in Nong-Suea District, Pathum Thani Province. The data was collected from 28-30 April 2014. Nong-Suea District contains 7 Sub-districts and 70 villages [3]. The description of the Sub-districts and villages are given as follows:

1) Bueng Ba 9 villages
2) Bueng Bon 9 villages
3) Bueng Gasam 9 villages
4) Bueng Cham Or 12 villages
5) Nong Sam Wang 13 villages
6) Sala Kru 10 villages
7) Nopparat 8 villages

3.2 Sample group and sampling procedure

This research systematically used random sampling method for the selection of the farmers within Nong-Suea District. The 10 participating farmers involved are categorized as follows:

1) Sala Kru 6 participants
2) Nopparat 2 participants
3) Nong Sam Wang 2 participants

3.3 Evaluation plan throughout the yard-long-beans growing process

The collected data was compared and divided into two groups as:

1) Basic data on the planting of yard-long beans and its greenhouse gas emission.

2) Sample data of the planting of yard-long beans and its greenhouse gas emission from the random sampling.

3.4 Data collection

This research utilized two information sources. They are:

1) The primary data was obtained from the sample group in the studied area. This information was collected through interviews with farmers. The details are as follows:

Section 1: Personal details
Location and characteristics of the agricultural land
Section 2: Economic background
Income (amount of production)
Section 3: Farmers' suggestions

2) Secondary data was obtained from other relevant reports, documents and publications and provide basic information for the research such as

(1) History of Nong-Suea District

(2) Nong-Suea's District general physical, political, and economic characteristics and its basic infrastructures

(3) Map of Nong-Suea District

(4) Basic information on yard-long beans and its planting process

(5) Information for assessing carbon footprint

3.5 Carbon footprint analysis

The formula used in calculating the carbon footprint of yard-long-beans is as follows:

$$GHG_{CO_2e} = AxEF \text{ [7]} \quad (1)$$

GHG = Amount of carbon dioxide equivalent (CO_2e)

A = Activities causing to greenhouse gas

EF = Coefficient of greenhouse gas emissions or Emission factor (in kg-CO_2e/unit)

Carbon footprint = Total amount of carbon dioxide emissions that is accumulated over the life stages of product X, with its potential being affected to climate change equivalent.

To calculate GHG, one needs to add the green-house gas emissions of each process to get the total emission throughout yard-long- beans' life cycle, as shown in Figure 1. Emission factor can be calculated from:

1) Actual measurements

2) Thai National Life Cycle Inventory Database

3) Information from these and other relevant researches

4) Other available databases such as those in different software, specific industrial databases, and country-specific databases

5) Information published by international organizations such as the IPCC Guidelines

The greenhouse gas emission factor of each activity (kgCO_2e/unit) equals the sum of the product between greenhouse gas volume (kg GHG/unit) and the global warming potential of that greenhouse gas (kg CO_2e/kg GHG)

4. Results

The results of the random sampling of 10 farmers from Nong-Suea District, Pathum Thani Province to assess greenhouse gas emission of yard-long-bean cultivation throughout its life cycle, can be found in table 2.

Table 1 Different steps associated with each stage of yard-long-bean cultivation.

Sourcing materials	Production and care	Transportation	Consumption	Waste disposal
- Seeds - Organic fertilizers - Chemical fertilizers - Pesticides - Fuels	- Seed preparation - Soil preparation - Planting holes preparation - Seed planting - Transplanting the seedlings - Watering - Adding teepee supports - Adding fertilizers - Pest control - Harvesting	- Distribution	- Eat raw	- Waste

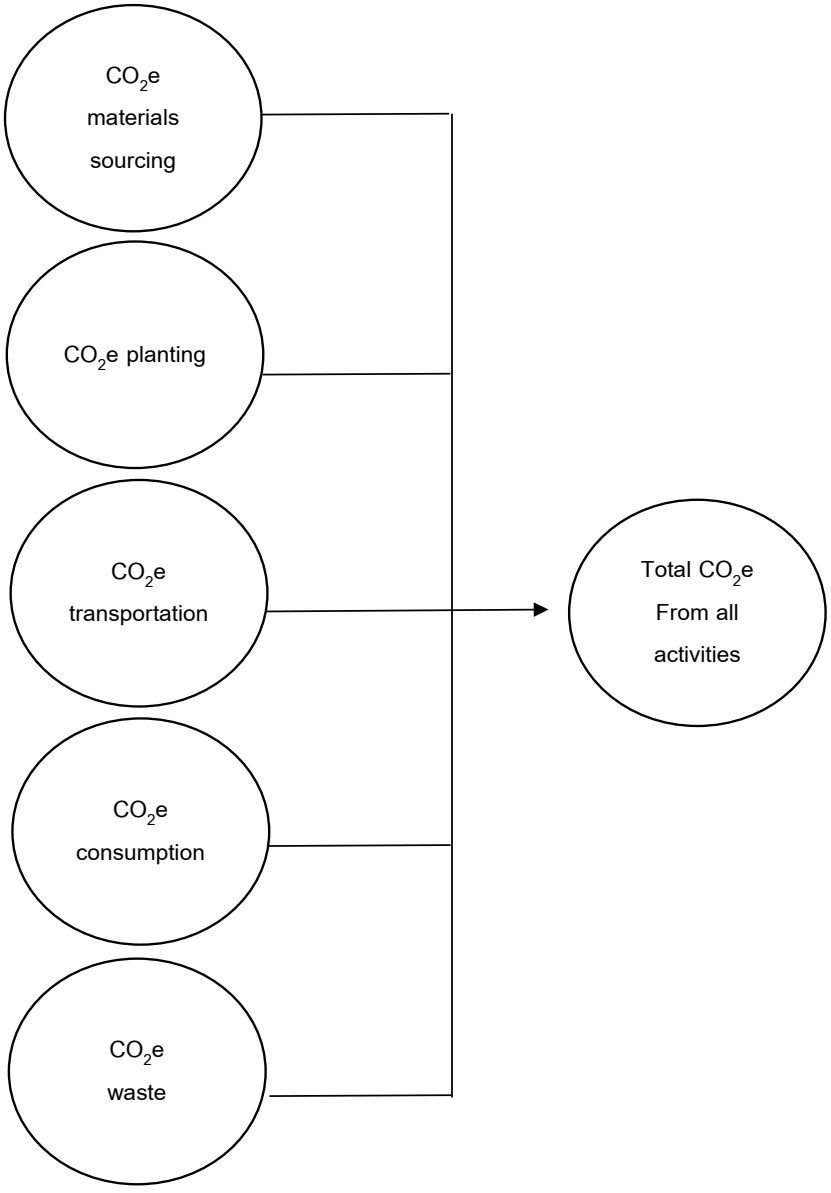

Figure 1 Total emission of greenhouse gases from all activities

Table 2 Results from the study of greenhouse gas emission through a life cycle of yard-long-beans for 10 farmers

Farmer/Procedure	Material sourcing	Production and care	Product distribution	Consumption	Waste disposal	Average ($kgCO_2e$)/ha
1	1.537	685.362	1.700	-	-	614.831
2	2.136	608.597	1.780	-	-	1914.106
3	2.305	108.270	1.068	-	-	348.887
4	0.178	94.018	1.280	-	-	298.362
5	1.537	144.322	2.065	-	-	462.262
6	1.537	666.542	3.720	-	-	419.875
7	1.537	225.845	3.774	-	-	206.387
8	3.074	558.380	3.310	-	-	705.956
9	1.537	517.384	2.734	-	-	599.643
10	1.537	887.793	3.750	-	-	1860.581

Note: For consumption, since the beans were eaten raw, no greenhouse gas emission occurred. In addition, there was also no emission due to waste disposal since no waste was found.

Table 3 Analysis of data deviations

Data source	Sum of squares	Df	Mean of squares	F	P-value
Process	1,367,739.660	2	683,869.830	25.271	0.000
Farmers	245,424.366	9	27,269.374	1.008	0.469
Deviation	487,105.324	18	27,061.407		
Total	2,100,269.350	29			

In the test, F1 = 25.271, it can be concluded that each process released different quantities of greenhouse gases at the P-value of <0.0009. Compared, to other assessed variables, the planting process released the highest level of greenhouse gases. The remaining variables did not have significant differences in GHG emissions. Additionally, since F2 = 1.008, it can be concluded that each farmer released approximately the same quantity of greenhouse gases at P-value of 0.469.

5. Discussion

This survey of yard-long-bean farming practices in Nong-Suea District, Pathum Thani Province indicated that the methods of farming were similar throughout the province. The planting production and care phase of the yard-long-bean life cycle had the highest release of GHG. Insight into the high level of GHG in the planting production and care phase is discussed below in steps that highlight fertilizers and pesticides as the reasoning behind the highest level of GHG emissions in the life cycle:

1) Material sourcing included seeds, fertilizers, soil and chemicals. The most common seed species for yard- long-bean cultivation were Kiewdok No.5 by Sorndeang and Lamnamshee by Sorndeang. Most farmers used fertilizers consisting of the formulas 16-16-16, 8-24-24, 25-7-7. The chemicals applied were mostly insecticides called Lannate (trade name) and Abamectin (common name). In addition, some fungicides were applied when yard-long-beans showed related symptoms.

2) To prepare the soil, the farmers dug holes to dry and spread it.

3) In preparing the planting hole, the farmers dug an average of 500-937 holes per ha. At some extremes, some farmer dug nearly 2,812 planting holes per ha. Some farmers applied organic fertilizers at the bottom of the holes, but the majority did not add any fertilizer during that stage.

4) In planting the seeds, 2-4 seeds were planted, the hole was covered and water was applied immediately.

5) There was no occurrence of transplantation of the seed's sprouts.

6) The farmers used bamboo, ropes, and nets to build a teepee-like structure which aids in the growth of the yard-long-bean.

7) The fertilizers used during the first phase of planting were mostly formula 25-7-7 and applied at a rate of 31-62 kilograms/ha. In some cases, formula 46-0-0 was applied at a rate of 18-56 kilograms/ha. In the second phase, when the bean pods started forming, fertilizer formula 16-16-16 at a rate of 12-62 kilograms/ha was used. Some farmers selected formula 8-24-24 at a rate of 31 kilograms/ha or a mixture of 16-

16-16, 13-13-21 and 0-0-21 at the ratio of 1: 1: 1. The fertilizer formulas selected by the individual farmer was based on their knowledge and experience in agricultural practices. The fertilizers were added every 7-10 days until the end of the harvest ended season. The total cultivation period for yard-long-beans range from 75-90 days.

8) To control weeds, pests and prevent diseases, the farmers cleared the weeds prior to building the teepees or like structures monitored the growing plots for, and immediately removing, weeds throughout the year. Additionally, the most common insecticides used by farmers were Lannate (trade name) and Abamectin (common name) applied at a range of 6-25 liters/ha every 7-10 days. Fungicides such as Cabandazim, which was applied only when the plants showed the corresponding symptoms.

9) Harvesting was generally conducted at a minimum of 45 days after planting, depending on which species was used and the general environmental conditions. During the harvesting period, beans can be picked every day or every other day.

10) Yard-long-beans are generally consumed raw, but it can also be used as ingredients in dishes such as Somtum (Thai spicy Papaya salad).

6. Conclusion

Greenhouse gas emission from yard-long-bean cultivation in Nong-Suea District, Pathum Thani Province averaged at 623.996 kgCO_2eq /ha and each process produced different quantities of greenhouse gases. The planting process and care variable produced the highest level of greenhouse gases and thus the largest having the largest carbon footprint associated with yard-long-beans. This is a result of utilization of different fertilizers and pesticides in this process. The remaining variables in the carbon footprint assessment did have an association of GHG emissions, however, it was equal or less than the planting process and care variable.

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