JOURNAL OF RUBBER RESEARCH

Quantification of Greenhouse gas emissions in the production of young budding of rubber in Malaysia

--Manuscript Draft--

Manuscript Number:	JRubbRes-D-17-00011R1
Full Title:	Quantification of Greenhouse gas emissions in the production of young budding of rubber in Malaysia
Article Type:	Original Study
Keywords:	young budding in the polybag; rubber bud-grafted; rubber nursery; greenhouse gas emissions; life cycle inventory
Abstract:	A study on the greenhouse gases (GHGs) emissions quantification was carried out with the objectives to quantify all the GHGs emissions and identify the main GHGs sources in the production of two whorl young budding in the polybag. The study was conducted using Simapro software version 7.3.3 based on the Intergovernmental Panel on Climate Change (IPPC) 2007 fourth assessment report (AR4) global warming potential (GWP) for 100 year-time horizon involving 32 rubber nurseries in Malaysia. The production and usage of N fertilizer, HDPE resin E production and diesel production are the four main processes contributors in releasing the GHGs emissions from the production of one two whorl young budding in the polybag. The GHGs emissions from these four main process contributors in the production of two whorl young budding in the polybag had the potential to be reduce through the reduction in the period to grown these young budding of rubber and increasing the bud-grafted success rate of the individual grafters.
Response to Reviewers:	Reviewer #1: 1. The study was good but not well presented. Elaborations of of M & M are necessary since the readers come from various background some of them are not familiar with the subject matter discussed even though they are well verse with rubber plants. We are not sure the meaning of 'M & M' as mentioned by Reviewer #1 thus no elaboration was made. Reviewer #1: 2. English can still be further improved. We take note on the comment and do some minor grammar changes in the manuscript. Reviewer #1:3. Please check on the format of the journal. Results followed by discussion and then, results on sensitivity analysis before conclusion is quite unfamiliar. Also, sensitivity analysis is just a comparison. We did check with the editorial office through email and the feedback that we got is that as long as the sensitivity analysis is written before conclusion, then it is still acceptable. Reviewer #2: - Author need to justify why he/she focus on GHG emission quantification only, while LCA can quantify a lot more environmental impacts. We are fully agreed with the Reviewer#2 comment that LCA can quantify a lot more environmental impacts. The justification on why this study is only focus on GHG emission quantification is because we want to identify the main process in the rubber nursery operation that contribute to the climate change impact (one of the parameter in LCIA). By identifying the main process contributors, possible ways to reduce the GHGs emission from the rubber nursery operation can be identify in line with the Malaysia commitment to reduce up to 40% of carbon emission intensity per GDP by 2020 as compared to 2005. Reviewer #2:

"In this study, the GHGs emissions from the usage of fuel in the machineries during the land clearing for nursery establishment is considered as insignificant and categorized as capital goods by1"- Explain in details why is it insignificant?

The usage of fuel in the machineries during the land clearing for nursery establishment is considered as insignificant due to:
1)It is a one-off activity involving some elements of fuel in the machineries that is difficult to quantify as it is only occur once for every rubber nursery. This amount of fuel is considered as insignificant as compared to the life span of rubber nurseries which can be operated as many years as possible as a result of this one off activity.

2)The amount of fuel used during this one-off the land clearing process is relatively very small and insignificant as compare to the amount of diesel used daily in the nursery water sprinkler system.
Reviewer #2:

"The real time GHGs emissions from diesel engine combustion to run water sprinkler system was also excluded from this study due to difficulty in obtaining data and inaccessibility of specific equipment during the study period" -explains if the exclusion will effect the representative of the final results.

The exclusion will not affect the representative of the final results. This conclusion is based on almost similar study by Halimah, M., Tan, Y., Nik Sasha, K., Zuriati, Z., Rawaida, A., & Choo, Y. (2013). Determination of Life Cycle Inventory and Greenhouse Gas Emissions for a selected oil palm nursery in Malaysia: A Case Study. Journal of Oil Palm Research, 25(3), 5.

Reviewer #2:
"1.84GgramCO2eq" -please use 1.84 tonnes of CO2eq

We change the units as suggested by Reviewer#2 in the manuscript

Reviewer #2:
this represent only 0.58% from the total GHG emission from the one year average of the GHG emission from the cultivation of rubber trees in Malaysia from cradle to grave" - Please explain how the 0.58% being obtained?

The 0.58% value is obtained when we compare the GHGs value from this study to total GHGs emissions from the one year average from the cultivation of rubber trees in Malaysia from cradle to grave (Reference No.15 in the manuscript).
Reference No. 15 is basically part of the on-going PhD project by the author and still not being published at present.

Reviewer #2:

The GHGs emissions from the production of one two whorl young budding in the polybag had the potential to be reduce if the usage of fertilizer N, usage of polybag in the form of HDPE resin E and the usage of diesel in the water sprinkler system are reduce significantly."- reduce by how many %?

From this study, it was confirm that the GHGs emission from the production of one two whorl young budding in the polybag had the potential to be reduce if the usage of fertilizer N, usage of polybag in the form of HDPE resin E and the usage of diesel in the water sprinkler system are reduce. A separate factorial experiment need to be done if we want to get the exact reduction value for each of the hotspot parameters and this is beyond the scope of this study.

Reviewer #2:

The reduction in the fertilizer N usage will directly reduce the amount of direct and indirect nitrous oxide emission."-reduce by how many %?

The percentage reduction in the amount of direct and indirect nitrous oxide emission as the
result from the fertilizer N usage is based on the formula below:

Nitrous oxide direct emission (Kg) = (N in Kg)*0.01*(44/28)

Nitrous oxide indirect emission as NOX and NH3 (Kg)=(N in Kg)*0.001*(44/28)

Nitrous oxide indirect emission after N leaching and run-off (Kg)= (N in Kg)*0.00225*(44/28)

Source for the above formula is listed below:

IPPC. (2006). 2006 IPPC Guidelines for National Greenhouse Gas Inventories. In Eggleston H.S., L. Buendia, K. Miwa, T. Nagara & K. Tanabe (Eds.). Japan: Institute for Global Environmental Startegies.

Reviewer #2:
"will resulted in the relatively lower value of GHGs emissions from the production of one two whorl" -reduce by how many %?

From this study, it was confirm that the reduction in the amount of diesel usage and polybag usage will resulted in the relatively lower value of GHGs emissions from the production of one two whorl. A separate factorial experiment need to be done if we want to get the exact reduction value for each of these two parameters and this is beyond the scope of this study.

Reviewer #2:
Sensitivity analysis need to be conducted on the exclusion of the GHGs emissions of diesel engine used to run water sprinkler system

We take note of the suggestion. As for this study, the specific equipment to measure the GHGs emissions of diesel engine was not available during the site visit to the rubber nurseries involved. The values for the GHGs emissions from diesel engine used to run water sprinkler system is also prdecited to be insignificant based on almost similar study by Halimah, M., Tan, Y., Nik Sasha, K., Zuriati, Z., Rawaida, A., & Choo, Y. (2013). Determination of Life Cycle Inventory and Greenhouse Gas Emissions for a selected oil palm nursery in Malaysia: A Case Study. Journal of Oil Palm Research, 25(3), 5.

Quantification of Greenhouse gas emissions in the production of young budding of rubber in Malaysia

ZAMERI MOHAMED*, ** AND SUMIANI YUSOFF *#

ZAMERI MOHAMED

*Department of Civil Engineering, Faculty of Engineering,

University of Malaya 50603 Lembah Pantai,

Kuala Lumpur, Malaysia.

**Rubber Research Institute of Malaysia,

Malaysian Rubber Board,

P.O Box 10150 Kuala Lumpur, Malaysia

*#SUMIANI YUSOFF

*Department of Civil Engineering, Faculty of Engineering,

University of Malaya 50603 Lembah Pantai,

Kuala Lumpur, Malaysia

Email:sumiani@um.edu.my

Telephone: +603- 7967 7807

Fax: +603-7967 7813

#(Corresponding author)

Abstract

A study on the greenhouse gases (GHGs) emissions quantification was carried out with the objectives to quantify all the GHGs emissions and identify the main GHGs sources in the production of two whorl young budding in the polybag. The study was conducted using Simapro software version 7.3.3 based on the Intergovernmental Panel on Climate Change (IPPC) 2007 fourth assessment report (AR4) global warming potential (GWP) for 100 year-time horizon involving 32 rubber nurseries in Malaysia. The production and usage of N fertilizer, HDPE resin E production and diesel production are the four main processes contributors in releasing the GHGs emissions from the production of one two whorl young budding in the polybag. The GHGs emissions from these four main process contributors in the production of two whorl young budding in the polybag had the potential to be reduce through the reduction in the period to grown these young budding of rubber and increasing the bud-grafted success rate of the individual grafters.

Keywords: young budding in the polybag, rubber bud-grafted, rubber nursery, greenhouse gas emissions, life cycle inventory

INTRODUCTION

Climate is an integral part of environment and climate change in more ways than one is a measure of abuse and mismanagement of this environment through time[1]. According to [2], human influence on the climate change is clear and the more we disrupt our climate, the more we risk severe, pervasive and irreversible impacts on human and natural system. The issue of climate change is more than just a warming trend as the increasing temperature through continued emissions of greenhouses gases (GHGs) will cause further warming and long lasting changes in all components of the climate system which will eventually lead to changes in major wind patterns, amount and intensity of precipitation and increased frequency of severe storms and weather extremes[1,2].

Malaysia ratified the United Nation Framework Convention on Climate Change (UNFCCC) on 13 July 1994 and the Kyoto Protocol on 4 September 2002[3]. As part of the obligations under the Article 4 of the UNFCCC, the Government of Malaysia submitted its Initial National Communication in July 2000 and the Second National Communication was submitted in January 2011[1,3]. Malaysia National Policy on Climate Change was approved by the Cabinet on 20th November 2009 with the policy statement to ensure climate resilient development to fulfil national aspirations for sustainability[4]. The National Policy on

Climate Change provides the framework to mobilize and guide government agencies, industry, communities as well as other stakeholders and major groups in addressing the challenges of climate change in an effective and holistic manner[5].

Malaysia greenhouse gases (GHGs) emissions for the year 2000 was 222.99 million tonnes CO2eq and the removal was 249.78 million tonnes CO2eq with a net sink of 26.79 million tonnes CO2eq[5]. As part of the sustainable development strategies for Malaysia, the Prime Minister had announced Malaysia's voluntary reduction of up to 40% in terms of carbon emission intensity of gross domestic product (GDP) by the year 2020 compared to 2005 level during his address to the 15th Conference of the Parties (COP) to the UNFCC on 17th December 2009 [5,6].

A rubber nursery can be considered as a factory producing planting materials before it is ready to be transplant into ~~the rubber~~ smallholders field[7]. As of March 2011, there are 110 licensed rubber nurseries in Malaysia and 103 of these ~~licensed rubber nurseries~~ are active producing the planting material ~~with~~ the total combined area of 1431.6 hectare[8]. The commonly produced planting materials by the rubber nursery industry are in the form of young budding in polybag, bare root budded stump, budded stump in polybag and green budstick[8,9]. A total of 19.367 million polybag units were produced from rubber nurseries operator in Malaysia for 2011 and young budding in polybag is the most popular form of planting materials representing 69.8% from the total production of polybag units[8].

In line with the global awareness on climate change and Malaysian National Policy on Climate Change, the Malaysian government through Malaysian Rubber Board (MRB) had formulated a strategy to promote the green image of Malaysian natural rubber through promoting Life Cycle Assessment (LCA) methodology as one of strategy in the One Nation Rubber Strategy[10]. The objective of this strategy is to make sure that by 2020 there is the availability of national average data on GHGs emissions for the whole sectors of rubber industry and the data will be use as a guide in formulating strategies to reduce the GHGs emissions from the whole sectors of the rubber industry[10]. The GHGs emission study on the production of young budding of rubber will be the first step towards the overall goal of quantifying the GHGs emissions from the whole sectors of rubber industry in Malaysia. In the context of Malaysian rubber industry, GHGs emissions quantification through LCA methodology is totally a new approach and the study on the quantification of GHGs emissions from the production of young budding of rubber by the rubber nurseries will be the first study ever conducted in Malaysia. The objectives of this study are therefore to quantify all the GHGs emissions and identify the main GHGs sources in the production of two whorl young budding in the polybag

MATERIALS AND METHODS

The GHGs emissions quantification was conducted using Simapro software version 7.3.3 based on the Intergovernmental Panel on Climate Change (IPPC) 2007 fourth assessment report (AR4) global warming potential (GWP) for 100 year-time horizon. In this study, the GHGs emissions from the usage of fuel in the machineries during the land clearing for nursery establishment is considered as insignificant and categorized as capital goods by[11]. The real time GHGs emissions from diesel engine combustion to run water sprinkler system was also excluded from this study due to difficulty in obtaining data and inaccessibility of specific equipment during the study period.

A total of 32 rubber nurseries in Peninsular Malaysia took part in this study and these respondents represent 29.1% from the total number of licensed rubber nurseries in Peninsular Malaysia. The life cycle inventory (LCI) for this study was carried out according to ISO 14040 and ISO 14044. The scope of this study was to perform a cradle to gate approach on the production of young budding of rubber within the boundary of the rubber nursery and the defined system boundary for this study ~~is~~ simplified in *Figure 1*.

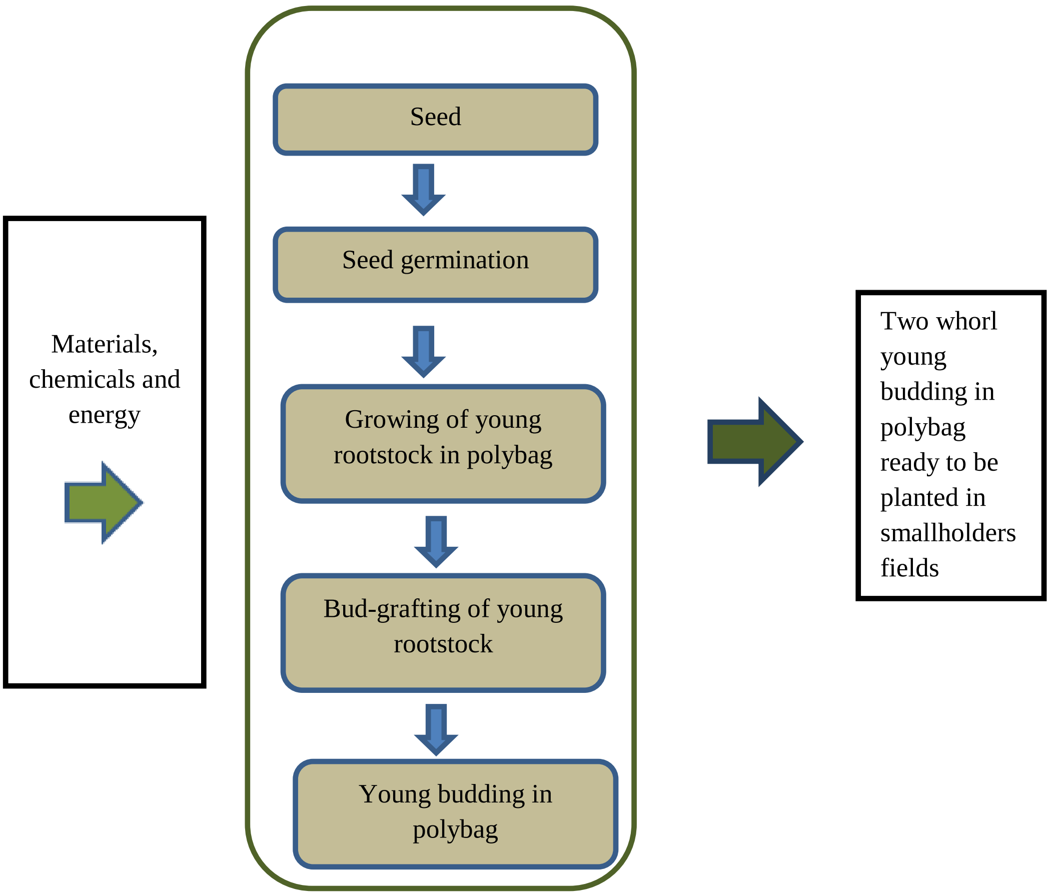

Figure 1. The define system boundary for the production of two whorl young budding in the polybag

The functional unit for this study i.e. the quantified performance of a product system for used as a reference unit as defined by[12] was based on the quantity of the two whorl young budding in polybag produced by the rubber nurseries ready to be planted at smallholders field. For this study, it was assumed that there was no significant quality differences of the two whorl young budding in polybag produced from all the respondents that took part in this study.

The two types of data involves in this study are foreground data and background data. The foreground data for this study were collected directly from the rubber nurseries operators through detailed questionnaire survey. The foreground data covered the information on the agronomic practices, fertilizers and plant protection application, diesel consumption for running the water pump and water consumption for irrigation. The foreground data from the survey were verified during the site visit to the majority of the respondents. For rubber nurseries which were not visited during this study, the foreground data were verified through email and telephone communication. The verified foreground inventory data from the survey were then analysed and summarized into Life Cycle inventory (LCI) table based on the production of one polybag of two whorl young budding. The background data for the inputs for this study were source from Ecoinvent database version 2.2, Industrial Data 2.0 database and LCA Food DK database which is embedded within the Simapro software and also from Pesticide Board, Department of Agriculture Malaysia online database[13].

RESULTS

Life cycle inventory

The LCI table quantifying the average inputs values for the production of one polybag of two whorl young budding for this study is shown in *Table 1*.

TABLE 1. LCI TABLE FOR THE PRODUCTION OF ONE POLYBAG OF TWO WHORL YOUNG BUDDING.

Input	Unit	Average value
Polybag	Kg	0.0130
N fertilizer	Kg	0.0042
P205 fertilizer	Kg	0.0042
K20 fertilizer	Kg	0.0039
Rock Phosphate fertilizer	Kg	0.0790
Magnesium oxide from Yellow NPK Compound fertilizer	Kg	0.0010
Fungicide with 80% w/w mancozeb as active ingredient	Kg	0.0009
Fungicide with 50% w/w chlorothalonil as active ingredient	Kg	0.0002
Insecticides (various active ingredients)	Kg	0.0003
River water	M3	0.2227
Diesel	L	0.0399
Emission	Unit	Average value
Nitrous oxide emission from N fertilizer usage	Kg	8.7005E-05

Greenhouse gas emissions

The GHGs emission from the production of one two whorl young budding in the polybag from this study is 1.299E-01 KgC02eq (Figure 2).

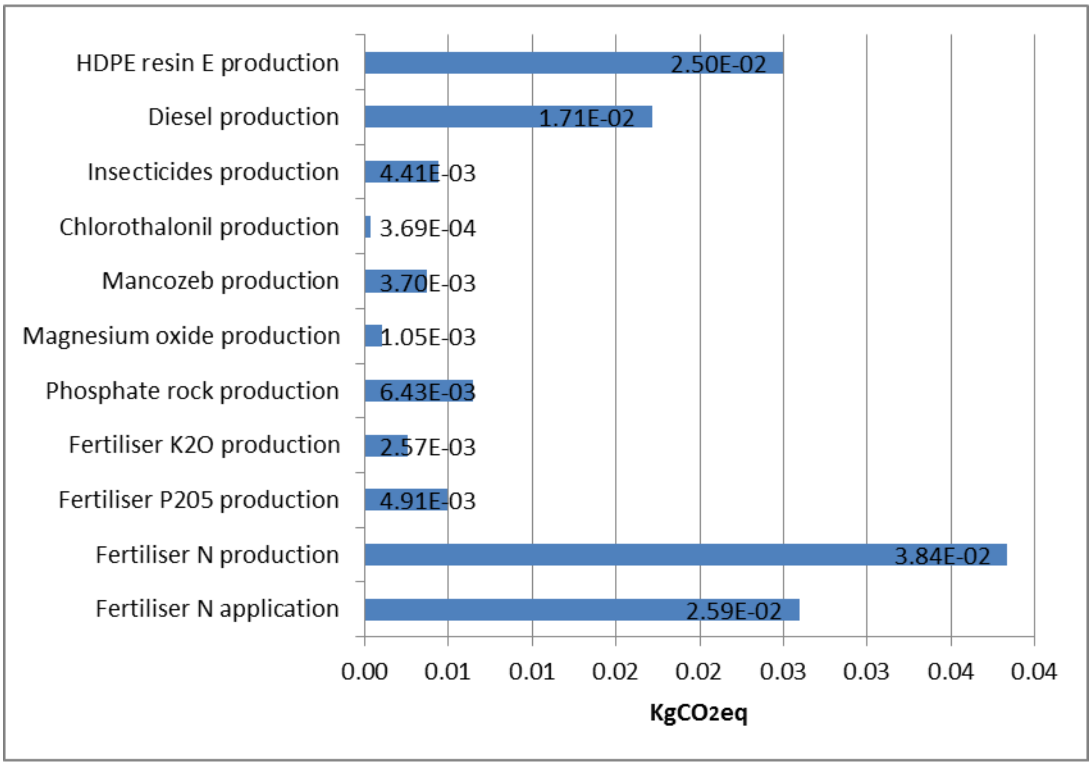

Figure 2: GHGs emissions value in the production of one two whorl young budding in the polybag based on process

Fertilizer N production is the highest process contributor representing 29.5% from the total GHGs emissions value in the production of one two whorl young budding in the polybag (Figure 2). The other main process contributors to the GHGs emissions in the production of one two whorl young budding in the polybag are fertilizer N application, HDPE resin E production and diesel production at 20.0%, 19.2% and 13.2% respectively (Figure 2). Phosphate rock production recorded 5.0% while the remaining 6 processes are considered as insignificant process contributors towards the total value of GHGs emissions in the production of one two whorl young budding in the polybag (Figure 2).

A total of 14170743 units of two whorl young budding in the polybag were produced from rubber nurseries operator in Malaysia for 2013[14].The GHGs emissions from the production of 14170743 units of two whorl young budding in the polybag is 1840 tonnes CO_2eq and this represent only 0.58% from the total GHG emission from the one year average of the GHG emission from the cultivation of rubber trees in Malaysia from cradle to grave[15].

The list of all GHGs that contribute to the total GHGs emission value in the production of one two whorl young budding in the polybag is shown in *Table 2*.

Table 2: GHGs emissions from the production of one two whorl young budding in the polybag

GHG	Weight in $KgCO_2eq$
Nitrous oxide	5.04E-02
Carbon dioxide	7.07E-02
Methane	8.78E-03
Sulfur hexafluoride	3.00E-05
Methane, tetrafluoro-, CFC-14	1.09E-05
Methane, bromotrifluoro-, Halon 1301	9.44E-06
Ethane, hexafluoro-, HFC-116	2.23E-06
Methane, tetrachloro-, CFC-10	1.72E-06
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	1.15E-06
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	1.04E-06
Methane, chlorodifluoro-, HCFC-22	8.97E-07
Methane, bromochlorodifluoro-, Halon 1211	2.36E-07
Methane, dichlorodifluoro-, CFC-12	1.57E-08
Methane, trifluoro-, HFC-23	8.80E-09
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	1.66E-09
Ethane, 1,1-difluoro-, HFC-152a	9.49E-10
Chloroform	2.60E-10
Methane, monochloro-, R-40	2.31E-11
Methane, trichlorofluoro-, CFC-11	1.44E-11

Methane, dichloro-, HCC-30	1.15E-11
Ethane, 1,1,1-trichloro-, HCFC-140	9.64E-12
Methane, dichlorofluoro-, HCFC-21	2.82E-13
Methane, bromo-, Halon 1001	2.11E-17
Total GHG EmissionS	1.299E-01

Carbon dioxide and nitrous oxide are the two major GHGs that contribute 93.2% from the total GHGs emission in the production of one two whorl young budding in the polybag (Table 2).

Carbon dioxide emission

Carbon dioxide emission represents 54.4% from the total GHGs emissions in the production of one two whorl young budding in the polybag (Table 2). The details of carbon dioxide emission from the production of one two whorl young budding in the polybag are shown in *Table 3*.

Table 3: Carbon dioxide emission based on process for the production of one two whorl young budding in the polybag

Parameter	CO_2 (Kg)
Fertiliser N	1.28E-02
Fertiliser P205	4.65E-03
Fertiliser K2O	2.38E-03
Phosphate rock	6.15E-03
Magnesium oxide,	1.04E-03
Mancozeb	3.47E-03
Chlorothalonil	3.39E-04

Insecticides	4.03E-03
Diesel	1.55E-02
HDPE resin E	2.04E-02
Total CO_2 Emission	7.07E-02

HDPE resin E production, diesel production and fertilizer N production are the three major carbon dioxide emission process representing 68.8% from the total value of carbon dioxide emission in the production of one two whorl young budding in the polybag (Table 3). Carbon dioxide emission from HDPE resin E production is the highest contributor representing 28.8% from the total value of carbon dioxide emission in the production of one two whorl young budding in the polybag (Table 3). The second and third highest contributor to the total value of carbon dioxide emission in the production of one two whorl young budding in the polybag is diesel production and fertilizer N production at 21.9% and 18.1% respectively (Table 3). The remaining 6 process are consider as minor contributors with contributions from 0.5% to 8.7% towards the total value of carbon dioxide emission in the production of one two whorl young budding in the polybag (Table 3).

The carbon dioxide emission from the production of 14170743 units of two whorl young budding in the polybag in Malaysia is 1.00GgramCO_2 and this represent only 0.75% from the carbon dioxide emission from one year average of the carbon dioxide emission from the cultivation of rubber trees in Malaysia from cradle to grave[15].

Nitrous oxide emission

Nitrous oxide emission represents 38.8% from the total GHGs emissions in the production of one two whorl young budding in the polybag (Table 2). The details on nitrous oxide emission for the production of one two whorl young budding in the polybag based on process are shown in *Table 4*.

Table 4: Nitrous oxide emissions based on process for the production of one two whorl young budding in the polybag

Parameter	N_20 (Kg)
Fertiliser (N)	8.07E-05
Fertiliser (P205)	1.58E-07
Fertiliser (K2O)	1.89E-07
Phosphate rock	1.88E-07
Magnesium oxide,	5.51E-09
Mancozeb	8.6E-08
Chlorothalonil	6.65E-09
Insecticides	3.41E-07
Diesel	2.95E-07
HDPE resin E	1.03E-14
N fertilizer usage	8.7E-05
Total N_20 Emission	1.69E-04

Nitrous oxide emission from the usage of fertilizer N and production of fertilizer N are responsible for 99.3% from the total nitrous oxide emission in the cultivation of one two whorl young budding in the polybag (Table 4). Nitrous oxide in the form of direct and indirect emissions from the usage of fertilizer N contributes 51.5% from the total value of nitrous oxide emission in the production of one two whorl young budding in the polybag (Table 4). Production of fertilizer N contributes 47.8% from the total value of nitrous oxide emission in the production of one two whorl young budding in the polybag (Table 4).

The nitrous oxide emission from the production of 14170743 units of two whorl young budding in the polybag in Malaysia is 2.39E-03Ggram N_20 and this represent only 0.0014% from the nitrous oxide emission from one year average of the nitrous oxide emission from the cultivation of rubber trees in Malaysia from cradle to grave[15].

DISCUSSIONS

The GHGs emissions from the production of one two whorl young budding in the polybag had the potential to be reduce if the usage of fertilizer N, usage of polybag in the form of HDPE resin E and the usage of diesel in the water sprinkler system are reduce significantly.

Fertilizer N usage in the production of one two whorl young budding in the polybag had the potential to be reduced through the reduction of period needed to produce two whorl young budding in the polybag. The two whorl young budding in the polybag which can be produced in 6 month time will definitely use less fertilizer N as compared to 12 month needed to produce two whorl young budding in the polybag.

The reduction in the fertilizer N usage will directly reduce the amount of direct and indirect nitrous oxide emission. Nitrous oxide is produced naturally in soil through the processes of nitrification and denitrification[16]. The emission of nitrous oxide from the soil can be increase through application of N fertilizer to the soil in the direct emission process[17]. According to Kramer *et al*. in [18], the application of N fertilizers contributed to direct emission of nitrous oxide as results of denitrification. Nitrous oxide is a gaseous intermediate in the reaction sequence of denitrification and a by-product of nitrification that leaks from microbial cell into soils and ultimately into atmosphere and one of the main controlling factors in this reaction is the availability of inorganic nitrogen in the soi1[16]. The indirect nitrous oxide emission are emissions that are induced by the N fertilizer use, but taking place elsewhere after nitrogen loses from the fertilized fields[17]. These losses include nitrogen leaching and runoff, and emissions of N fertilizer as nitrogen oxides or ammonia[17]. Nitrous oxide only represent 0.6% from the total value of GHGs emission in the production of fertilizer N but due to its global warming potential of 298, nitrous oxide is the highest contributor in the GHGs emission for the production of fertilizer N at 62.7%[19].

From the total number of rubber nurseries operators in this study, 31.3% recorded the period to produce two whorl young budding in the polybag of more than 9 month. Certain agronomic practices that can lead to shorter period in producing the two whorl young budding in the polybag need to be identified in order to reduce the GHGs emissions from the production of two whorl young budding in the polybag. The identification of these agronomic practices however was not identified in this study due to time limitation and within outside the scope of this study. The reduction in the period to produce two whorl young budding in the polybag will also contributes in reducing the diesel usage in the water sprinkler system.

The usage of polybag in the form of HDPE resin E and the usage of diesel in the water sprinkler system can be reduce increasing the bud-grafted success rate. By employing very experience and skilled grafters, the bud-grafted success rate can be achieved up to 92.3%[20]. The selection of good quality seedling from recommended clones to produce young rootstock and the selection of good quality bud-patches from recommended clone to be grafted to young rootstock will also definitely enhance the bud-grafted success rate.

The increase in the bud-grafted success rate will reduce the number of discarded young rootstock in the polybag that failed the bud-grafted process and this will lead to overall reduction in the amount of diesel used and the number of polybag needed to produce two whorl young budding. The reduction in the amount of diesel usage and the number of polybag usage will resulted in the relatively lower value of GHGs emissions from the production of one two whorl young budding in the polybag. From this study it was found that the increase of 14.8% in the bud-grafted success rate will translated into the reduction of 13.2% from the total GHGs emission in the production of one two whorl young budding in the polybag. Based on the survey data, 40.6% of rubber nurseries operator in this study recorded the bud-grafted success rate of below 80% due to difficulty in getting a very experience and skilled grafters as one of the main reasons. We don't have the exact figure on the average of bud-grafted success rate from all the rubber nurseries in Malaysia but we expected the figure will be in the range of our study i.e. from 60-90%.

Sensitivity analysis based on different type of polybag usage in the production of young budding of rubber

Sensitivity analysis is a comparison of the results obtained using certain given assumptions, methods or data with the results obtained using altered assumptions, methods or data[21]. During the survey verification visit, it was noticed that there are few rubber nurseries operators that used the relatively cheaper low density polyethylene (LDPE) polybag in their operations even though majority of the rubber nurseries operators are using the HDPE polybag due to the robustness of the HDPE polybag. As HDPE resin E production is one of the major process contributors in the production of one two whorl young budding in the polybag, a sensitivity analysis was done to compare the GHGs emissions value from the usage of this two types of polybags.

The list of all GHGs emissions from the usage of HDPE polybag and LDPE polybag in the production of one two whorl young budding in the polybag is shown in *Table 5*.

Table 5: GHGs emissions from different types of polybag usage in the production of one two whorl young budding in the polybag

GHG	Production of one two whorl young budding in the polybag **(KgC0$_2$eq)**	
	HDPE polybag	LDPE polybag
Carbon dioxide	7.07E-02	7.22E-02
Chloroform	2.60E-10	2.60E-10
Nitrous oxide	5.04E-02	5.04E-02
Ethane, 1,1-difluoro-, HFC-152a	9.49E-10	9.49E-10
Ethane, 1,1,1-trichloro-, HCFC-140	9.64E-12	9.64E-12
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	1.15E-06	1.15E-06
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	1.66E-09	1.66E-09
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	1.04E-06	1.04E-06
Ethane, hexafluoro-, HFC-116	2.23E-06	2.23E-06
Methane	8.78E-03	9.46E-03
Methane, bromo-, Halon 1001	2.11E-17	2.11E-17
Methane, bromochlorodifluoro-, Halon 1211	2.36E-07	2.36E-07
Methane, bromotrifluoro-, Halon 1301	9.44E-06	9.44E-06
Methane, chlorodifluoro-, HCFC-22	8.97E-07	8.97E-07
Methane, dichloro-, HCC-30	1.15E-11	1.37E-11

Methane, dichlorodifluoro-, CFC-12	1.57E-08	1.57E-08
Methane, dichlorofluoro-, HCFC-21	2.82E-13	2.82E-13
Methane, monochloro-, R-40	2.31E-11	2.31E-11
Methane, tetrachloro-, CFC-10	1.72E-06	1.72E-06
Methane, tetrafluoro-, CFC-14	1.09E-05	1.09E-05
Methane, trichlorofluoro-, CFC-11	1.44E-11	1.44E-11
Methane, trifluoro-, HFC-23	8.80E-09	8.80E-09
Sulfur hexafluoride	3.00E-05	3.00E-05
Total GHG emission	1.30E-01	1.32E-01

Carbon dioxide and nitrous oxide are the two main GHG contributors to the total GHG emission in the production of one two whorl young budding from the usage of HDPE polybag and LDPE polybag (Table 5). Carbon dioxide and nitrous oxide contribute 93.2% and 92.8% respectively towards the total GHGs emissions from the usage of HDPE polybag and LDPE polybag in the production of one two whorl young budding in the polybag (Table 5).

The GHGs emission from the production of one two whorl young budding from the usage of LDPE polybag is 1.7% higher but not considered as significantly difference from the GHGs emission from the usage of HDPE polybag. If the possibility of rough handling by the rubber nurseries workers is taking into consideration, the possibility of tearing from the usage of the LDPE polybag during the filling of top soil is relatively higher as compared to more robust HDPE polybag. By taking this scenario into account, it might be possible that the GHGs emission from the usage of LDPE polybag is much higher than the GHGs emission from the usage of HDPE polybag in the production of one two whorl young budding in the polybag.

CONCLUSION

The production and usage of N fertilizer, HDPE resin E production and diesel production are the main processes contributors in releasing the GHGs emissions from the production of one two whorl young budding in the polybag. The two possible approaches which can reduce the GHGs emissions from the production of two whorl young budding in the polybag are through reduction in the period to grown these young budding of rubber and increasing the bud-grafted success rate of the individual grafters. Research works to identify agronomic practices that can lead to a shorter period in producing the two whorl young budding in the polybag should be prioritize and promoted to the rubber nursery industry in the form of standard operation procedure as it will help in reducing the GHGs emissions from this industry.

The skills in bud-grafting for individual grafters can be increase through the assistance from the rubber related agencies in Malaysia in the form of training on the correct bud-grafted technique. The rubber nursery industry in Malaysia has huge potential to reduce their GHGs emissions from their production of two whorl young budding in the polybag by concentrating their efforts to increase the bud-grafted success rate. The increase in the bud-grafting success rate from the rubber nursery industry in Malaysia is not only help in reducing its total GHGs emissions but indirectly it can be translate into a lower consumption of resources by the rubber nursery industry. The reduction of resources consumption in the production of two whorl young budding in the polybag is not only good for the environment but also good in terms of reducing the operation cost of the rubber nursery industry as most of the fertilizers and chemicals used in the production of two whorl young budding is imported from oversea. The rubber nurseries operators also need to be educated on the important to use good quality seedlings and proper selection of good quality bud-patches from recommended clones in order to increase the bud-grafted success rate.

ACKNOWLEDGEMENTS

The assistance from Mr. Wan Zuraidi Sulaiman, Research officer of Malaysian Rubber Board, Mr. Kameruzaman Ab. Rahman, Head of Unit Dasar Perlesenan & Permit, LGM and his staff, Mr. Mohd Desa Abdullah from LGM Sungai Petani, Dr. Yahya Abd. Karim and Mr. Yunos Kasir from Felda Agriculture Services are greatly acknowledged.

REFERENCES

1. SHAM, S. (2009). The Politics of Climate Change: International Responses and Malaysia. Institut Alam Sekitar dan Pembangunan (LESTARI), UKM, Bangi, Selangor

2. IPPC. (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K Pachauri and L.A Meyer (eds).] (pp. 151). Geneva, Switzerland: IPPC.

3. UNDP. Third National Communications (TNC) to the UNFCCC and Biennial Update Reporting (BUR) for Malaysia. Retrieved 29 July 2015, 2015, from http://www.my.undp.org/content/malaysia/en/home/operations/projects/environment_and_energy/third-national-communications--tnc--to-the-unfccc-and-biennial-u.html

4. MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT MALAYSIA. (2010) National Policy on Climate Change

5. MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT MALAYSIA. (2011) Second National Communication to the UNFCCC. Putrajaya, Malaysia

6. Gary, W. T.(2013). Roadmap to achieving the 40% carbon intensity emissions reduction. Paper presented at the REDD+ Stakeholder Consultation Workshop, Sunway Putra Hotel, Kuala Lumpur.

7. MALAYSIAN RUBBER BOARD (2009). *Rubber plantation & Processing Technologies*. Malaysian Rubber Board, Kuala Lumpur

8. RAMLI, O. AND SHARIFAH, N.S.N.(2012) Pemantauan Pengeluaran Bahan Tanaman Getah:Salah satu aktiviti dibawah Projek NKEA. *Buletin Sains & Teknologi*, **10**(1), 39-42.

9. WAN ZURAIDI, S., NOORLIANA, M.Z. AND MALIK, Y. (2009) Establishement and Management of Rubber Nursery. *Buletin Sains & Teknologi*, **5**(1), 11-14.

10. MALAYSIAN RUBBER BOARD. (2014) *One Nation Rubber Strategy*. Malaysian Rubber Board, Kuala Lumpur

11. SUMIANI, Y. (2006). Feasibility of Life Cycle Management for Improved environmental management-Case study on Malaysian Palm Oil Industry. (Phd Thesis), University of Malaya, Kuala Lumpur

12. INTERNATIONAL STANDARD ORGANIZATION. (2006) *ISO 14040- Environmental management- Life cycle assessment-Principles and framework*, ISO, Geneva

13. PESTICIDE BOARD MALAYSIA. (2015). List of registered pesticides database. Department of Agriculture Malaysia Web. http://www.doa.gov.my/senarai-racun-makhluk-perosak-berdaftar. Acess 3rd November 2013.

14. MALAYSIAN RUBBER BOARD. Laporan PS-2. Available from Malaysian Rubber Board eSemaian Retrieved 6th January 2014 http://uip.lgm.gov.my/esemaian/Login.aspx

15. ZAMERI, M AND SUMIANI, Y. Unpublished data.

16. IPPC. (2006). 2006 IPPC Guidelines for National Greenhouse Gas Inventories. In Eggleston H.S., L. Buendia, K. Miwa, T. Nagara & K. Tanabe (Eds.). Japan: Institute for Global Environmental Startegies.

17. JAWJIT, W., KROEZE, C., & RATTANAPAN, S. (2010). Greenhouse gas emissions from rubber industry in Thailand. Journal of Cleaner Production, 18(5), 403-411. doi: http://dx.doi.org/10.1016/j.jclepro.2009.12.003

18. NORLIYANA, Z. (2012). Life Cycle Assessment of Greenhouse Gases Emission from Nitrogen fertilizer application in Palm Oil Industry. (Master of Engineering Science thesis), University of Malaya, Kuala Lumpur.

19. NIELSEN PH, NIELSEN AM, WEIDEMA BP, DALGAARD R, & N, H. (2003). LCA Food database. https://lca-net.com/projects/show/lifecycle-assessment-basic-food/ http://gefionau.dk/lcafood/www.lcafood.dk.

20. HIDZIR, A.K. AND SHAMSUDDIN, A. (1991) Semaian benih cantuman muda dan prestasinya di Mini Estet Bukit Berapit- pengalaman PPK Parit/ Blanja. *Siaran Pekebun,* **120**, 72-78.

21. INTERNATIONAL STANDARD ORGANIZATION.(2006) *ISO14044-Environmental management-Life cycle assessment- Requirements and guidelines*, ISO,Geneva