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EFFICIENT USE OF CROP RESIDUES FOR PRODUCING ENERGY AND ENHANCING SOIL CARBON SEQUESTRATION AS CLIMATE SMART PRACTICES IN RURAL AREAS OF VIETNAM

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Nguyen Van Thiet[1], Cao Huong Giang[*1]

Abstract

This article presents results of research on the efficient use of crop residues in energy production and land carbon fixation in Ha Tinh, Yen Bai and Bac Lieu. MHH-IAE 003 was a product designed and tested by IAE, suitable for many kinds of materials such as: rice husk, sawdust, peanut husk, maize corn, wood chips. Compared to similar stoves, MHH-IAE 003 stove was more effective on heat management and air pollution reduction. Biochar get high organic carbon and CEC. The biochar was applied to soil, combined with changes in mineral fertilizers in experiments in Ha Tinh, Yen Bai, Bac Lieu. The experiment in Yen Bai showed that use of 1.5 tons of biochar per hectare increased corn yield and decreased 20% of chemical fertilizer. Rice in Bac Lieu also reached the similar results. The peanut experiment sites in Ha Tinh, with the same amount of NPK applied but the greater amount of biochar also got more productive than the other formulas. In 3 experiments, biochar method led to increase the amount of organic matter. Cation exchange capacity (CEC) was proportional to the amount of organic matter. Apply biochar increased soil carbon higher than convention. This research has initially led to a successful approach to changing farmer's crop residue treatment methods, using with a new, more efficient and sustainable way of reducing greenhouse gas emissions.

Keywords: Gasifier, biochar, crop residues, Yen Bai, Ha Tinh, Bac Lieu

INTRODUCTION

Agricultural activity is known to be the sector most affected from climate change, is also a large contributor of greenhouse gas emissions (14%). Factors regulating the GHGs emissions from agricultural activities are many, among others, over use of chemical fertilizer, over irrigation, etc. Burning crop residues in the fields is part of the problem, will be increased in the future as modern cooking facilities replace crop residues cooking devices. While

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crop residues are burnt to clean the field, soil organic carbon is depleting as consequence of intensification, desertification, and soil erosion. Currently, almost half of Vietnam's agricultural land area is considered 'barren land' (9.3 million ha among 21 million ha), featuring extremely low level of productivity (World Bank, 2004).

Biochar produced by pyrolysis of biomass residues contains a significant proportion of the feedstock carbon and is very recalcitrant to biological decay (Knoblauch *et al.*, 2011). Biochar is viable option for reducing GHGs emission, enhancing soil fertility and saving cost of fertilizers as it potentially reduces nutrient leaching (Lehmann *et al.*, 2006). Biochar is well known for its potential for GHGs mitigation while simultaneously increasing crop yields (Zhang *et al.*, 2010). The production and application of biochar derived from crop residues on field soils is therefore a promising alternative for organic matter management in farming systems, which could combine positive long-term effects on soil quality and GHG reduction by carbon sequestration in soils.

Based on the technology developed by the Institute of Agricultural Environment (IAE) (Mai Van Trinh, 2012; Tran Viet Cuong, 2010) to gasify crop residues produce biochar, the objectives of this study are to efficiently use crop residues for home fuel and soil amendment aiming at to increase crop yield and halt GHG emissions rates through improvement of soil fertility and soil carbon sequestration in Yen Bai, Ha Tinh and Bac Lieu provinces.

MATERIALS AND METHODS

Materials

Energy and biochar produced were focused from crop residues (i.e. rice straw, rice husk, corn cob). The gasifier using in this study was modified by IAE's team for suitable conditional: crop residual type, time consuming, stove's material. Biochar were collected from gasifying process will be applied to the soils to improve soil fertility and halt soil degradation process

Methods

Field demonstration was established in 3 sites (Yen Bai, Ha Tinh and Bac Lieu) with different treatments. The formula used in the experiment were: additional 1.5 tons and 3 tons of biochar. The control formula was used as recommended by the local agricultural extension agent. For experiments on maize in Yen Bai and rice in Bac Lieu, combined with a 20% reduction in inorganic fertilizers. Experiment on peanut in Ha Tinh, the same amount of NPK fertilizer applied. The experiments were repeated three times. Biochar samples were analyzed to evaluate its quality. Soil sampling method was based on Vietnam standard TCVN 5297-1995. Soil analyzing was followed by Vietnam standard. Crop growth and crop yield were observed and measured during the crop season following as IRRI and Vietnamese Standard.

Methods of analysis of the efficiency of the experiment

Economic analysis:

Total income = Price × Real yield

Total cost = Total variable cost and opportunity cost

Net Interest = Total income – Total cost

Time and place of the study

Time of the study: Autum-winter 2015.

The project was implemented in three sites at household and community level/scale: Site 1 in the Northern Mountainous Region (Vinh Kien commune, Yen Binh district, Yen Bai province); Site 2 in the Northern Central (Ky Son commune, Ky Anh district, Ha Tinh province), and Site 3 in the Mekong River Delta (Chau Thoi commune, Vinh Loi district, Bac Lieu province). The reason for selecting these provinces as below: Among three selected provinces Bac Lieu representing for rice growing in Southern Vietnam while substantial area of maize is grown in Yen Bai, representing for quickly expanding area of maize in Northern parts in recent decades (from 9 thousand ha in 1995 to 76 thousand ha in 2012). Peanut crop in Ha Tinh was selected as it's grown area increased over observed period (1995 - 2012) in the region (GSO Vietnam, 2013).

RESULTS AND DISCUSSION

Modification of existing biomass gasifier from crop residues by IAE

IAE team has developed the gasifier as a means to mitigate GHG emission from various farm and household activities. It made use of crop residues, which various types include: rice straw and hulls, sawdust and corn cobs, to produce energy for household cooking. Other by-products including organic biochar as soil enhancer and a tarry liquid that could be used as bio-pesticide. The gasifier made by IAE's team has been modified for suitable conditional: crop residual type, time consuming, stove's material. Gasifier cooker stove and biochar named MHH. There are three advantages: Create biogas to cook every day, friendly environment and using conveniently. Stove MHH could use with

3 purposes: Burning agricultural residue to create biogas for cooking; create charcoal, biochar for cooking, fertilize, to make pot soil to grow vegetable; and create biological pesticide. Structure of stove MHH is quite simple with a capacity of 60 liters, can hold 12 - 15 kg husk; or 10 - 12 kg rice straw; or 15 - 20 kg firewood. Time for burning can last 1 - 5 hours, and create 4 - 8 kg biochar depend on materials.

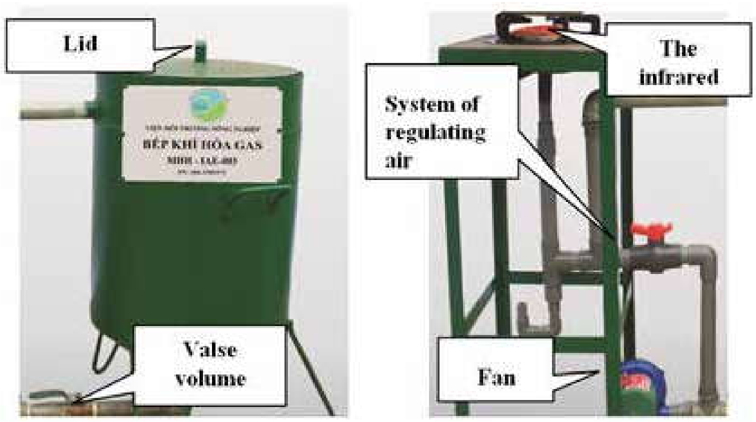

Figure 1. Gasifier cooker stove and biochar named MHH-IAE 003

In this study, the performance of MHH-IAE gasifier stove was compared with another similar product (Table 1).

Burning time/kg fuel of MHH-IAE 03 stove reaches equivalent to industrial gas stove and higher than DK-T5 stove. The percentage of biochar/fuel also reach highest in 3 stoves and reach 28 - 33%, more than 1.6 - 1.7 times into the remaining 2 stoves. Especially, about reducing pollution emissions, the IAE 03 MHH stove has reduced 80 - 90% CO and 70 - 80% other gases during cooking. DK-T5 stove and industrial husk stoves have only reduced 35 - 50% CO and 30 - 46% other gases. Therefore, MHH-IAE 003 stove is more effective on heat management and air pollution reduction than similar stoves on the market.

Table 1. Comparing the effectiveness of MHH-IAE 03 gasifier stove with other similar products

Performance metrics		MHH-IAE 03 stove	DK-T5 stove	Husk industrial stove
Picture				
Material		Husk, sawdust, husk firewood…	Husk, sawdust, husk firewood…	Husk, sawdust, husk firewood…
Max. Temp.		1,250°C	950°C	1,100°C
Calorie (KJ/m^3)		12.000	8.700	11.500
Max. material (kg)		Husk (10-12 kg), sawdust (14-15 kg), husk firewood (15-17 kg)	2 kg husk firewood, 1 kg husk	4 kg husk, 6 kg husk firewood
Burning period/kg material		30 - 35 minutes	25 - 30 minutes	30 - 40 minutes
The rate of biochar/fuel (%)		28 - 33	16 - 20	18 - 20
Minimizing pollution	CO (%)	80 - 90	35 - 49	30 - 50
	Other air (%)	70 - 80	43 - 46	30 - 40
Price (VND)		3,000,000	1,445,0000	1,980,000

Biochar sample analyzed

Testing result of produced biochar showed that: Biochars were rich in organic carbon. Biochars had much higher content of OC, exchange cation capacity (CEC). Total content of nitrogen (N) was 0.152 - 1,326%, content of phosphorous (P) was 0.25 - 0.30% and content of potassium (K) was 0.4 - 0.7% dependent on the type of biochar.

Table 2. Biochar made quality in study site

No	Criteria	Unit	Biochar	
			Rice straw	*Peanut*
1	Humid	%	66.50	68.25
2	OC	%	16.33	29.43
3	N total	%	0.152	1,326
4	P total	%	0.39	0.242
5	K total	%	0.78	0.436
6	CEC	cmocl/kg	20.85	21.06
7	Ca2+	cmol/kg	5.00	5.09
8	Mg2+	cmol/kg	2.02	2.07

Biochar-based product application in demonstration pilots

Biochar fertilizer for corn cultivation land in Yen Binh District, Yen Bai Province

Apparently, the biochar treatment had a big influence in corn yield, which performed by higher yield in biochar treatment than in farmers' treatment and higher yield caused by more biochar applied. CT2, CT3 with biochar application had high yield and income from workday compared to control treatment. K, OC, CEC were increased in treatment 3 compared to CT0 and other treatment.

Biochar fertilizer for peanuts cultivation land in Ky Anh District, Ha Tinh Province

The experiments assess the effectiveness of biochar for peanuts in Ha Tinh were arranged with 2 types of biochar: Biochar from the husks and peanut shells with 5 treatments.

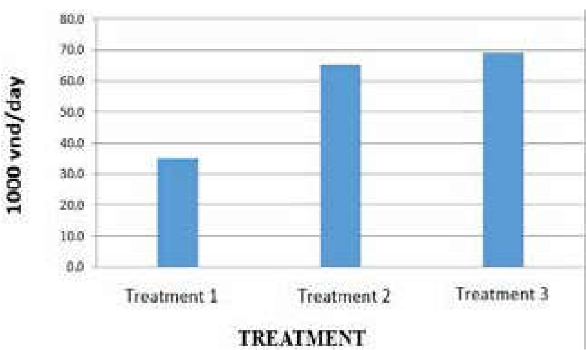

Figure 2. Income from workday in every single treatment in Yen Binh

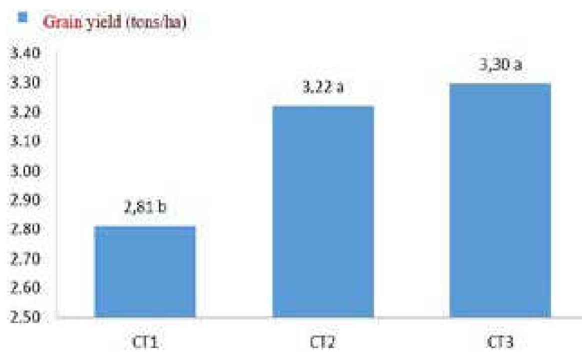

Figure 3. Actual corn yields in experimental treatments in Yen Binh

Table 3. Chemical properties of the soil in Yen Binh

Plot	N (%)	P_2O_5 (%)	K2O (%)	OC (%)	CEC (cmol/kg)	Ca^{2+} (cmol/kg)	Mg^{2+} (cmol/kg)
CT0 (Before experiment)	0.265	0.108	0.761	2.15	12.4	1.67	1.11
Treatment 1	0.258	0.102	0.581	2.33	12.3	1.66	1.12
Treatment 2	0.244	0.095	0.760	2.36	12.2	1.66	1.13
Treatment 3	0.259	0.104	0.773	2.42	13.6	1.88	1.20

Notes: Treatment 1: farmers' practice; Treatment 2: decrease 20% chemical fertilizers, 1.5 tons of biochar fertilizer/ha; Treatment 3: decrease 20% chemical fertilizer, 1.5 tons of biochar fertilizer/ha.

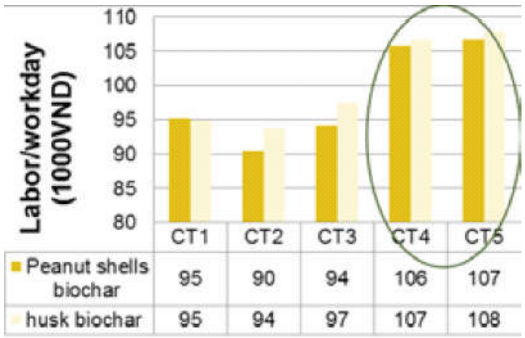

Figure 4. Income from workday in every single treatment in Ky Anh

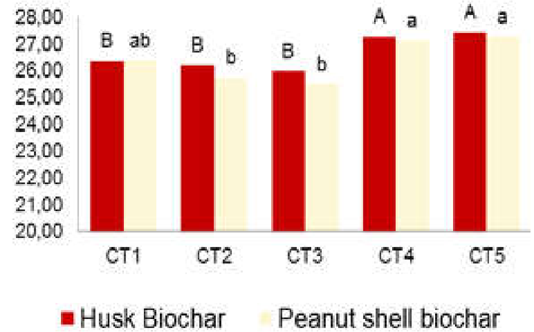

Figure 5. Actual corn yields in experimental treatments in Ky Anh

Table 4. Chemical properties of the soil in Ky Anh

Treatment	N (%)	P_2O_5 (%)	K2O (%)	OC (%)	CEC (cmol/kg)	Ca^{2+} (cmol/kg)	Mg^{2+} (cmol/kg)
CT0	0.063	0.048	0.064	0.074	15.04	3.67	1.06
Treatment 1 (Control)	0.058	0.277	0.441	1.007	15.27	2.10	2.17
Treatment 2	0.063	0.266	0.172	1.119	14.02	1.93	1.00
Treatment 3	0.065	0.284	0.191	0.912	15.32	2.10	1.75
Treatment 4	0.066	0.258	0.414	0.812	17.72	2.95	1.85
Treatment 5	0.051	0.209	0.297	1.036	16.06	2.33	1.57

Notes: Treatment 1: farmers' practice: 6,000 kg manure fertilizer + 400 kg Nghe An fertilizer + 600 kg lime + 45 N + 60 K_2O; Treatment 2: 300 kg manure fertilizer + 400 kg Nghe An fertilizer + 600 kg lime + 2,700 kg biochar + 45 N + 60 K_2O; CT3: 300 kg Nghe An fertilizer + 1,500 kg biochar + 600 kg lime + 35 N + 45 K_2O; Treatment 4: 300 kg Nghe An fertilizer + 3,000 kg biochar + 600 kg lime + 35 N + 45 K_2O; Treatment 5: 300 kg Nghe An fertilizer + 4,500 kg biochar + 600 kg lime + 35 N + 45 K_2O.

The results showed that the more amount of biochar fertilized applied, the higher of yield and the income also increased, whether biochar from rice husk or peanut shell. In chemical of soil, OC and CEC increased in biochar application compared to control pilot.

Impact assessment of biochar on rice in Tra Hat village, Bac Lieu province

Impact assessment of biochar on rice in Tra Hat village, Bac Lieu province showed in Tab.5.

Table 5. Actual yields and cost-benefit assessment in different treatments

Treat-ment	MH1			MH2			MH3		
	Yield (kg/ha)	*Increase yield (%)*	*Net profit (VND/ha)*	*Yield (kg/ha)*	*Increase yield (%)*	*Net profit (VND/ha)*	*Yield (kg/ha)*	*Increase yield (%)*	*Net profit (VND/ha)*
T1	5,934	-	-	6,580	-	-	5,357	-	-
T2	6,355	7.1	2,418,650	7,142	8.54	3,102,500	5,785	7.99	2,452,600
T3	6,447	8.6	3,203,970	7,157	8.77	3,514,370	5,863	9.45	3,170,020

Notes: Treatment 1: farmers' practice; Treatment 2: decrease 20% chemical fertilizers, 1.5 tons of biochar fertilizer/ha; Treatment 3: decrease 20% chemical fertilizer, 1.5 tons of biochar fertilizer/ha.

After demonstration, soil samples were taken from plots and treatments to analysis. Compared to soil before experiment, soil pH was a little increased, pH values from 5.84 to 6.00 were obtained in treatments which biochar or biochar products were applied. The total content of OC, total P2O5 and CEC had changed in the same trend with pH values. Other parameters were similar to the initial soil. The results showed that soil acidity was improved, the pH was 0.406 - 0.409 unit. The amount of organic matter in treatments changed depending on each method with the lowest amount in NPK and the highest amount in composting. Thus, biochar method led to increase the amount of organic matter. Cation exchange capacity (CEC) was proportional to the amount of organic matter. Application of biochar increased soil carbon higher than convention in Bac Lieu.

Table 6. Chemical properties of the soil in Bac Lieu (average of MH1, MH2, MH3)

Indicator		T1	T2	T3
pH		4.06	4.09	4.07
CEC (meq/100 g)		13.36	13.52	13.66
OM (%)		3.69	3.82	3.86
N (total) (%)		0.16	0.20	0.20
P_2O_5 (%)		0.11	0.12	0.12
K2O (%)		2.29	2.36	2.36
Ca (total) (%)		0.08	0.07	0.08
Mg (total) (%)		0.32	0.29	0.32
Soil texture	Coarse sand (%)	0.20	0.36	0.26
	Fine sand	16.89	17.98	20.04
	Limon (%)	31.74	38.48	38.16
	Clay (%)	51.16	43.18	45.54

CONCLUSIONS

CCAFS research on climate-smart technologies and practices addresses the challenge of how to transition to a climate-smart agriculture (CSA) at a large scale for enabling agricultural systems to be transformed and reoriented to support food security under the new realities of climate change. In this study, biochar from crops residue with gasifier stove is a choice to practice CSA.

- Economic value from using gasifier stove when people use MHH-03 may save 3,800 VND/day and respectively 1,417,660 VND/year, a significant amount for rural areas, and also can save chemical fertilizer and increase crop yields when applying biochar into the soil. Although the MHH-IAE 003 gasifier stove has higher initial cost than common stove, operating costs is much lower and durability, safety and nearly the risk of explosion as a gas stove. Especially this gasifier stove is suitable for household scale in rural areas, mountainous areas in our country, people will take advantage of agricultural by-product on site, avoid wasteful burning, ensuring health and does not pollute the environment.

- Environmental efficiency was demonstrated by applying biochar on crop land. If manure were applied 10 tons/ha, after 1 season carbon in manure will decompose and release CO_2 out after one to two seasons. If applying 10 tons/ha of biochar can accumulate over 33% of the carbon in the biochar. The amount of chemical fertilizer applied to soil also reduces when applying biochar and also contribute to reducing emissions of greenhouse gases, such as N_2O, CH_4 in the atmosphere. Biochar method lead to increase the amount of organic matter. Cation exchange capacity (CEC) is proportional to the amount of organic matter. Application of biochar could increase soil carbon higher than convention.

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MARKET INFORMATION TRANSFER SYSTEM (MITS) IN THE RICE VALUE CHAIN IN THE MEKONG DELTA, VIETNAM

Pham Cong Nghiep*[1], Vu Van Doan[1]

Abstract

The research in the world indicated that MITS considerably influenced farmers' production and trade, it increased the efficiency of agricultural production, the income of farmers and improved the living condition of farmers. However, studying and applying MITS in the reality in the Mekong delta of Vietnam were still limited. This paper will analyze the current situation of MITS in the rice value chain in the Mekong delta, Vietnam from 315 farmers' survey in 2017. The findings of the survey showed that: Majority of rice farmers in the Mekong delta of Vietnam have been accessing to market information from many sources such as relatives, friends, village leaders, traders, collectors, agricultural extension system, television, etc and through some channels face-to-face meetings, phone, television, radio, etc. Rice farmers' satisfaction on MITS was still low because they have met some obstacles during market information seeking and usage such as low quality of market information, lack of market information sources and channels, lack of governmental agencies participation in MITS, etc. Rice farmers' educational level, household size, rice income and amount of market information channels had a significant influence on farmers' satisfaction on MITS in rice value chain in the Mekong delta, Vietnam.

Keywords: Market information transfer system, market information sources, market information channels, Mekong delta, rice value chain

INTRODUCTION

Rice plays an important role in Vietnamese life and economy. According to Do Thi Thu Ha (2012) rice subsector was occupying 40% of gross output of Vietnamese agriculture, 9.3 million households were planting paddy (65% of rural households). During the period of 2010 to 2017, Vietnam averagely exported 6.06 million tons of rice with its value of 2.609 billion USD annually (General Statistics Office, 2017).

The Mekong delta is rice granary in Vietnam. This region contributes up to 50% of national rice output and 90% of rice export. However, the main issues in rice sector in the Mekong delta is low profit of rice farmers. According to a study of Tran Cong Thang *et al.* (2013) showed that the average income of rice farmers from rice production in the Mekong delta was very low with 535,000 VND/month (about 25 USD/month).

Market information system plays an important role in raising the efficiency of economic performance and helps farmers enter the market better, sell more products with higher prices (Sultan Freihat, 2012).

The demand of improving the market information system is imperative and a great significant to rice farmers in the Mekong delta, Vietnam. The competitive pressure of rice farmers in the Mekong delta is more and more growing because with the development of science and technology, they have produced more and more the rice output, many rice farmers need to sell a bigger amount at the same time and so they need to find out the larger markets to sell the more rice with higher price. There are more and more intermediates between rice farmers and final customers and export companies in the Mekong delta and these intermediates became a barrier for the market information flow in the rice value chain,

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