Current Situation and Possibilities of Rice Straw Management in Vietnam

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Abstract:

Vietnam is the world's fifth-largest rice-producer all over the world, meaning that it has the fifth-largest rice straw quantity. Rice straw has both calorific value and nutrient value. At 10% moisture content, the energy content of this agricultural waste is approximately 14MJ per kilogram (Zafar, 2015), similar with the content of stacked and air dry log wood (Biomass Energy center, 2010). Regarding to content values, reports indicate that about 40% of the nitrogen (N), 30% -35% of the phosphorus (P), 80%-85% of the potassium (K), and 40%-50% of the sulphur (S) taken up by rice plants remains in rice straw after harvest. In addition, every year Vietnam has around 67 million tons of dry rice straw available. Thus, managing rice straw is not only a challenge but also an opportunity to utilize the available resource and reduce agriculture's climate footprint in an agricultural country like Vietnam.

Currently, Vietnamese farmers have been encouraged by government to implement alternatives rice straw management practices, such as: mushroom cultivation, fertilizer, feed, fuel and biomass production. Legislation on environmental protection in general and agricultural environmental protection in particular have been issued and been in effect for over 20 years. However it does not directly address the issue of rice straw management method.

10 years ago Vietnamese farmers chose to collect the straw for cattle feeding and fuel for cooking, but with the decrease in number of cattle and buffalos due to increased mechanisation, development of industrial cattle feed and use of gas stove, most modern farmers choose to burn their rice straw, while only some incorporate the straw into the soil by ploughing instead, as a cheap disposal method. Recent research reveals that while in the rural areas, 30-40% of the rice straw is burnt on the field; the figure in the suburban area is at 60-70%. That practices contributes to the air pollution and human health threat to the neighbourhood area. In particularly, Gadde calculated that 1kg of rice straw burnt directly on the field will emit 1,46 kg of carbon dioxide, 34,7 gram carbon mono oxide and 56 gram of dust (flying and ash). If 50% of rice straw were burn in Vietnam, there would be around 100 million tons of carbon oxide emitted.

To refrain air pollution from impact of burning rice straw, it is suggested to adapt modern technology instead of the traditional use of straw. According to that, incorporation, mushroom cultivation, compost and bio-char are discussed to find out its strength and weakness.

Resume: Current Situation and Possibilities of Rice Straw Management in Vietnam

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1. Introduction

Vietnam is the world's fifth-largest rice-producer all over the world, meaning that it has the fifth-largest rice straw quantity. Rice straw has both calorific value and nutrient value. At 10% moisture content, the energy content of this agricultural waste is approximately 14MJ per kilogram (Zafar, 2015), similar with the content of stacked and air dry log wood (Biomass Energy center, 2010). Regarding to content values, reports indicate that about 40% of the nitrogen (N), 30% -35% of the phosphorus (P), 80%-85% of the potassium (K), and 40%-50% of the sulphur (S) taken up by rice plants remains in rice straw after harvest (Dobbermann and Fairhurst 2002). Thus, managing rice straw is not only a challenge but also an opportunity to utilize the available resource and reduce agriculture's climate footprint in an agricultural country like Vietnam.

This study will review the current use of rice straw and discuss the possibilities of alternative rice straw management in Vietnam.

2. Objectives

This study aims to describe the situation of rice straw management in Vietnam, including an estimation of the rice straw quantity, related regulation and laws and its actual use in Vietnam. In addition to that, a review of existing alternative rice straw managements (covering incorporation, bio-char, compost and mushroom cultivation) in Vietnam will be made. These main management methods have both socio-economical and environmental value and they are already implemented or under experiment in Vietnam for recent 5 years.

3. Material and methodology

The study will review existing articles (including academic papers, conferences, laws and regulations and newspaper articles) from scientific journals and reports published by leading multilateral organizations, non-profit organizations, research institutes and ministries. To estimate the rice residue quantity (Q_s), the data relates to rice production (Q_R), residue to product ratio (RPR) and moisture content (k) is used (Koopman, 1997). Following by that, the amount of rice straw will be evaluated by the formula: $Q_S = Q_R*RPR*k$. In which: Qs is quantity of rice residue (dry ton); Q_R is rice production (ton); RPR is Residue to product ratio and k is moisture content. Rice has the ratio between rice straw to rice production (RPR) is 1.757 when the moisture content (k) is 12.71% (Koopman, 1997).

Furthermore, the contribution and density of rice straw generated will be varied depending on each region in Vietnam. For example, delta area will likely have greater proportion of rice-planted area on total area than the figure of mountainous area. These differences may affect to the choices of rice straw management. Thus, in this research, we also consider about the density of rice straw availability on different regions in Vietnam. The density of rice straw is calculated using the following equation: $D= q_s*d$. In which: D is the density of rice straw (dry t km^{-2} $year^{-1}$); q_s is the yield of straw (dry t $km^{-2}year^{-1}$) and d is the rice-planted area density. The data for rice production, rice yield, rice planted area and total area of each region in Vietnam is achieved from the Statistical Yearbook of Vietnam 2013. The rice-planted area density is the ratio of rice planted area to total area.

4. Result and discussion

4.1 Current situation of rice straw management in Vietnam

4.1.1 Estimation of rice straw quantity

The quantity and density of rice straw in 6 different regions in Vietnam is estimated (Table 1). The total amount rice straw generated in Vietnam in 2013 is approximately 67 million dry ton. In which, the two deltas (Mekong River Delta and Red River Delta) have high density of rice straw generated due to higher ratio between rice-planted area and rice yield compared to the other regions. To be specific, region 6, Mekong River Delta, accounts for roughly 56% of the total amount, following by the Red River Delta (region 1) with 15%. Furthermore, it is suggested that with a higher density of rice straw generated, region 6 and region 1 may favor large to medium scale of rice straw treatment facility (provincial to regional scale) due to the decrease of transportation cost. In other hand, since the rice straw generated is not concentrated, the transportation might be high, suggesting a small to medium scale of rice straw treatment facility (family-use to communal use).

Table 1: The quantity and density of rice straw generated in different regions of Vietnam

Region	Rice production (dry thousand ton)	Rice straw quantity (dry thousand ton)	Rice straw density (dry ton/km^2)
Red River Delta (1)	6,698.0	10,273	487.8
Northern Midlands and mountain areas (2)	3,275.8	5,024	52.73
Northern Central and Central Coastal Areas (3)	6,600.7	10,123	105.63
Central Highlands (4)	1,162.8	1,783	32.64
South East (5)	1,345.8	2,064	87.49
Mekong River Delta (6)	24,993.0	38,331	944.77
Total	44,076.1	67,599	204.24

Source: Statistical Yearbook of Vietnam 2013 and estimated

4.1.2 Laws, regulation on rice straw management

Currently, Vietnamese farmers have been encouraged by government to implement alternatives rice straw management practices, such as: mushroom cultivation, fertilizer, feed, fuel and biomass production. Legislation on environmental protection in general and agricultural environmental protection in particular have been issued and been in effect for over 20 years (Hai et all, 2010) however it does not directly address the issue of rice straw management method. Rather than a system of laws and regulation, the local authorities and local media seems to try raising the public awareness to the rice straw management method by publishing guidelines and organizing training course for farmers. Especially, in 2012, Ministry of Rural and Agriculture Development published the Guidelines on using efficient energy in agriculture, involving rice straw issue. Following by that, in 2012, the People Committee of Hanoi approved the Program to process agriculture residues into feed for husbandry. This proves that both local governments and central government concerns about the problem of agriculture residues.

4.1.3 Current use of rice straw

10 years ago Vietnamese farmers chose to collect the straw for cattle feeding and fuel for

cooking, but with the decrease in number of cattle and buffalos due to increased mechanisation, development of industrial cattle feed and use of gas stove, most modern farmers choose to burn their rice straw, while only some incorporate the straw into the soil by ploughing instead, as a cheap disposal method. Recent research reveals that while in the rural areas, 30-40% of the rice straw is burnt on the field; the figure in the suburban area is at 60-70% (Nguyen, 2012 and Tran et al, 2014). That practices contributes to the air pollution and human health threat to the neighbourhood area.

More specific, a survey was conducted in main crop provinces of region 6 in 2014 about the quantity and management method of rice straw (Tran et al, 2014). According to that survey, there are six common types of rice straw treatment and management: burning, burying (incorporation), mushroom cultivation, breeding, selling and giving to neighbours. 98,2% of rice straw generated in the winter-spring season was burnt directly on the field. In the autumn-winter season, due to frequent rain, the rate of burning rice straw was decrease into 54.1%. This survey also confirms that most of farmers tended to continue burning rice straw in the following years.

Burning of rice-straw is a major source of air pollutants, such as carbon dioxide (CO_2), carbon monoxide (CO), un-burnt carbon, methane (CH_4), nitrogen oxide (N_2O), and sulphur dioxide (SO_2) (Gupta et al, 2004; Wassman and Dobbermann 2006). More specific, Gadde calculated that 1kg of rice straw burnt directly on the field will emit 1,46 kg of carbon dioxide, 34,7 gram carbon mono oxide and 56 gram of dust (flying and ash) (Gadde, 2009). In addition to decreased air quality and visibility, the emission from rice straw burning also contains dioxins and furans, which has an even more secretive impact on human health (Torigoe et al.2000; Gadde et al, 2009).

The environmental cost for this practice is also high. If 50% of rice straw was burnt and the price for CO2 on IPCC is 15USD/ton (Springer, 2002), in 2013, Vietnam Government had to pay roughly 740 million USD for only carbon dioxide emission.

Thus, there is a need to refrain from burning the rice straw into alternative management method. In this research, we will focus in four types of rice straw management, involving: incorporation, straw mushroom cultivation, compost and bio-char. In which, incorporation and straw mushroom cultivation were adapted in Vietnam for a longer time than the newly invented compost and bio-char.

4.2 Alternative rice straw management

4.2.1 Incorporation

In Japan and some developed countries in the world, rice straw is chopped into small pieces and incorporated into the soil. In long term, this practice can increase soil organic matter, maintaining good soil structure and provide a valuable source of plant nutrients, such as phosphorus and potassium. In addition, straw incorporation can result increase of soil organic matter and carbon storage.

In Vietnam, since most rice fields in Vietnam are harvested by hand, the leftover of rice-straw (approximately half of rice straw) will remain on field. The remainder will be directly incorporate into the soil. This may leave a persistent straw barrier, which roots cannot penetrate. Thus, a chopper machine is required. In addition, incorporation will take time for straw decomposing and this may result a delay in subsequent crop. Normally, Vietnam has two or three seasons of rice every year, the transition time is about 15-20 days long. Recently, in Vietnam, a newly invented biotic product, namely Fito-Biomix RR, will shorten the process of decomposing straw. This biotic produc is now

under experiment in some provinces of northern Vietnam.

On the other hand, research proves that rice straw will take available nitrate or ammonium nitrogen out of the soil for its own decomposition, due to its high carbon level (Nicholson et al, 2014). This can cause the lack of nitrate in the soil, resulting an increase of applied fertilizer (Jenkinson, 1985).

Incorporation rice straw also has threat of disease. The crop residues may carry pathogens in dead lives and in the stem bases and roots. The threat will be varied depending on the disease severity, location of the straw and pathogen survival on straw in addition to crop (host) and weather factors (Nicholson et al, 2014).

Though incorporation is easy, the process takes time, proper chopper machine and bio-medical product to shorten the decomposing time of rice straw. Thus, this method could be applied in some discrete area and where farmers have a better opportunity cost rather than other methodology requiring straw removal.

4.2.2 Straw mushroom cultivation

Straw mushroom cultivation was introduced as a means increase farmer's income since the 1990s. There has been numerous of training, media support and straw mushroom forum in Vietnam. According to a survey conducted in 2013, all the farmer-respondents in region 6 knew about straw mushroom (Ngo et al, 2013). However, due to a limited market, limited spore supply and increasing labor cost, only 12% of the respondent had grown the crop (Ngo et al, 2013).

First of all, straw for mushroom cultivation requires straw with a special conditions relating to lengths, moisture. Straw mushroom cannot grow on bad quality of straw unless straw is mixed with other supplement to provide enough nitrate and moisture. Tackling this matter requires knowledge and skill of farmers when mixing straw with other material to have a better spore.

Secondly, mushroom cultivation is also labor intensive. This management method requires special patience and care. To encourage them, farmers can make use of the free and simple labor available in the commune or can work in groups to help each other to save on labor.

Last but not least, since mushroom has a high perishability, farmers need to sell their products within a day in the market. This could be one of the biggest challenges to the farmers when the output has not been secured. To address this problem, an union or cooperative of farmers should stand out to help the growers have a better access to the market and secure their minimum selling prices.

Due to the challenge mentioned above, it is supposed that a big scale of mushroom cultivation could be settled up in region 6 and region 1 because of a low transportation cost, professional workers and a sustainable market for its outcome.

4.2.3 Compost

Compost is the relatively stable product that results after organic materials decompose. Compost usually contains relatively low amounts of major nutrients but they contain micronutrients, enzymes and microorganisms that are not often found in inorganic fertilizer. The process of decomposing rice straw generates high temperature, around 55^0C, keeping pathogen level low and reducing the viability of weed seeds may contain in rice straw.

However, with low level of nitrate, compost from rice straw could not supply enough nutrients to achieve high yields. Composting also generates a significant amount of potent greenhouse gases

(GHG), methane and nitrous oxide though it is much better than burning directly on the field. Furthermore, compost process is labor and time intensive. Straw must be removed from the field before piling and spreading in the field. The decomposing will take at least 1 to 1.5 month. And the price of compost product from rice straw has not been introduced.

Though, there are several prospects for compost product from rice straw when a newly invented biotic products namely Fito-Biomix RR has been introduced in Vietnam. With a small amount (200g biotic product for 1 ton of rice straw) it helps to shorten the decomposing time of rice straw into 20 days to 1 month. With a cheap price (10USD for 1 kg of bio-products), easy implementation, farmers tends to adapt with this products when they have spare time and area for composting process. This management method could be applied in most of regions in Vietnam, though there might be chance to set up a big scale of compost facility in the delta regions, region 6 and region 1.

4.2.4 Bio-char

Bio-char is biologically derived charcoal, produced by the thermo-chemical pyrolysis of biomass material (McHenry, 2008). Many studies on the impacts of bio-char on crop productivity and soil fertility have found that bio-char itself does not help in adding nutrients to the soil but it could be used to increase the pH level in acidic areas and, more importantly, for carbon sequestration (Galinato, 2011). In Vietnam, there are several studies on the use of bio-char to improve soil fertility, increase crop yields and reduce greenhouse gas emissions. Rice straw also has a high calorific value, similar with the content of stacked and air dry log wood (Biomass Energy center, 2010). By making bio-char, we could use both the bio-char product and the recovery of heat.

However, since rice straw is light, making bio-char from rice straw requires more investment than other material like bamboo or even rice husk. Though there is already an experiment model implementing in Vietnam could make bio-char from rice straw, the productivity of this model is still low and not capable with the amount of rice straw generated. This model is also time consuming, not suitable with the requirement of fast straw removal. Furthermore, there is also a challenge when the amount of rice straw price for the output has not been secured yet.

Thus, there is a need to create a better facility for rice straw with higher capacity and productivity. There should not be a limitation on the scale of bio-char facility. In a dense area with rice straw (region 6 and region 1), the rice straw could be collected and transported to a communal or provincial bio-char facility with low cost of transportation. Based on that, an optimal size of bio-char facility could be proposed with cost and benefit analysis.

5. Conclusion

In a nutshell, rice straw is abundant in Vietnam but mainly is concentrated in the two delta regions (region 1 and region 6). Currently, Vietnamese farmers tend to burn rice straw after harvesting (70-80% in the north and nearly 90% in the south). This practice emits not only great amount of greenhouse but also very harmful toxic to human health. There are several alternatives management methods mentioned above, incorporation, mushroom cultivation, compost and bio-char. In which, incorporation could be applied in most of regions in Vietnam, favored the discrete farms where they do not have a better opportunity cost. In return, mushroom cultivation and compost could be upgraded into a big scale (communal, provincial and regional) to save the production cost, labor cost. Bio-char is under experiment but it could be widely applied because making bio-char technically is faster than

other methods and it helps in carbon sequestration process.

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