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THE POTENTIAL OF RICE STRAW IN AGRICULTURAL ACTIVITIES IN THE MADA REGION OF KEDAH, MALAYSIA

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ABSTRACT

Ineffective straw management by open field burning, leaving it on the field, and dumping it in landfill causes serious environmental degradation and adversely affects public health. This study assesses the level of farmers' knowledge on straw potential and the benefits of using straw in agricultural activities. Descriptive analysis was carried out on 160 farmers in the Muda Agricultural Development Authority (MADA) agricultural region in Kedah who manage straw in an environmentally-friendly manner. Results show that most of farmers lack knowledge in using straw in agricultural activities. The interviews revealed that the re-use of straw in the agricultural activities would enhance soil quality, improve the growth quality of plant, improve livestock and seedling germination, increase yield production; and reduce the cost of farm management. Given the economic value and high potential, straw could stimulate the wider rural economy through added-value as well as generally increase the socioeconomic class of farmers and improve the agricultural environment.

Contribution/ Originality: The paper's primary contribution is finding that the rice sub-sector should move towards managing agricultural residue by improving and strengthening the straw potential in agro-industrial development. Farmers need to increase their knowledge of straw management in contributing to the environmentally-friendly management and increasing the agribusiness of farmers.

1. INTRODUCTION

The rice industry is a strategic industry for many countries in Southeast Asia. Apart from being the staple food, the rice industry is a major contributor to the rural economy. The increase of rice yield by using high-yielding varieties of seeds and the practices of intensive farming, indirectly boosts the quantity of straw (Man *et al.*, 2003). It is estimated that more than 700,000 hectares of paddy field in Malaysia will produce 2 million metric tonnes of straw in each cultivation season (Jusoh *et al.*, 2013).

Straw is considered as a waste product by most farmers in Malaysia (Rosmiza *et al.*, 2014). Traditionally, straw has being managed by open burning in the field (Bird *et al.*, 2002; Erenstein, 2011), being left on the farm, ploughing directly into the field, being moved to other sites, being used as a plant growth medium and being used by household

for domestic uses (Zhang and Jenkins, 2004; Hanafi *et al.*, 2012; Rosmiza *et al.*, 2014; Oladosu *et al.*, 2016). Meanwhile, the straw that is left in the field without proper management will spread plant diseases and allow pests and rodents to infest and damage the next cultivation season (Jusoh *et al.*, 2013; Rosmiza *et al.*, 2014). Without burning straw, it is difficult to eliminate the life cycle of pests and diseases (Rosmiza *et al.*, 2014).

However, the straw that is left in the field takes about three to four weeks for the natural composting process to take place. This relatively long period of composting hampers the management of the land for the next crop season. During this period, the straw that is left in the field will release methane (CH4) (Doberman and Fairhurst, 2000; Mandal *et al.*, 2004; Hanafi *et al.*, 2012; John, 2013; Silalertruksa and Gheewala, 2013) and nitrous oxide (N2O) (Rice Knowledge Bank, 2016).

Most of the farmers prefer to manage their straw through on-farm open burning. This method is the cheapest and easiest way due to the time constraint in preparing land for the next cultivation season (John, 2013; Rosmiza *et al.*, 2015; Oladosu *et al.*, 2016). The significant effects of burning straw are observable in the threat of global climate change and its effect on human health (Hanafi *et al.*, 2012; Quayle, 2016). Open burning of straw contributes to greenhouse gas emissions (GHGs) such as carbon dioxide, methane and nitrous dioxide (Scheewe, 2010; Indian Agricultural Research Institute, 2012; Chang *et al.*, 2013). In addition, it also leads to the loss of most of the nutrients in the soil, namely, 93% nitrogen (Scheewe, 2010) phosphorus (25%), potassium (20%) and sulfur (5-60%) (Dobermann and Fairhurst, 2000; Mandal *et al.*, 2004) and silica (Scheewe, 2010).

Straw consists of panicle rachis, leaf blades, leaf sheath and the stem that are left after the harvesting season (Rosmiza *et al.*, 2014; Oladosu *et al.*, 2016). The composition of straw is made up of 35-50% cellulose; 15-30% hemicellulose; 20-30% lignin and a small amount of ash and nitrogenous (Zhang and Jenkins, 2004). In fact, straw contains nutrients such as nitrogen (N), phosphorus (P) and a relatively high amount of potassium (K) (Ismail *et al.*, 2013; Allen-Stevens, 2014; RKB, 2016) Table 1.

Table-1. Nutrient content in rice straw.

Nutrient content	Percent (%)	Nutrient content	Percent (%)
Silicon (Si)	5.5	Sulphur (S)	0.075
Potassium (K)	1.40	Manganese (Mn)	0.045
Nitrogen (N)	0.65	Iron (Fe)	0.035
Phosphorous (P)	0.10	Zinc (Zn)	0.003
Calcium (C)	0.30	Boron (B)	0.001
Magnesium (Mg)	0.20	Copper (Cu)	0.0003

Source: Ismail *et al.* (2013).

The concern about the environment and public health and the high potential of straw has opened up opportunities for the commercialization of straw in agro-industrial development by means such as composting, livestock feed and plant growth medium. In view of the high potential of rice straw in the agro-industrial development, it is uneconomical and a loss to the country if the resources are wasted. In fact, the adverse effects of rice straw management which is not environmentally-friendly and its effect on the environment and human health are also questionable. Thus, this study attempts to identify the level of knowledge of farmers on the potential of straw in agricultural development such as farming and livestock sector. The study also attempted to analyze the impact of the utilization of rice straw among farmers who reuse straw in their farm activities.

2. LITERATURE REVIEW

2.1. The Potential of Rice Straw in Agricultural Activities

2.1.1. The Potential of Rice Straw as Livestock Feed

Most of the rice producing countries use rice straw as a source of food for livestock feed. Straw is used for livestock feed when forage is in short supply or affected by drought (Quayle, 2016). The nutritional quality of rice straw as animal feeding varies depends on the maturity level of the plant, fertilization stage (nitrogen), soil fertility,

rice varieties, the ratio of leaf sheath, leaf blade and stem, the cutting method and the length of straw, plant resistance to pests, the time period between the harvesting process and the storage (Zhang and Jenkins, 2004) plant health, and the weather conditions (the degree of lighting and temperature) (Malik *et al*., 2015; Oladosu *et al*., 2016).

Rice straw could provide a good source of energy for livestock. The high fibre content permits rice straw to be given fresh or dry without any preservative as a hearty meal for livestock (Devendra, 1989). However, the low raw protein content and high lignin and silica level affect the livestock's digestive processes (Hanafi *et al*., 2012). Rice straw contains only 3-5% raw protein compared to 8-10% of the basic needs of the livestock and good growth (Oladosu *et al*., 2016). Furthermore, the poor palatability and low nutritional value makes it limited in use for livestock feed (Zhang and Jenkins, 2004; Malik *et al*., 2015; Quayle, 2016). Thus, the commercialization of rice straw as livestock feed with additional physical, biological and chemical treatments has been carried out to improve its nutritional value (Hon *et al*., 2000; Hanafi *et al*., 2012; Malik *et al*., 2015; Oladosu *et al*., 2016).

2.1.2. The Potential of Rice Straw as Compost

Rice straw is an organic source which contains micronutrients, enzymes and other micro-organisms that are beneficial for plant growth and soil fertility (RKB, 2016). Straw compost has proved particularly useful in stabilizing soil structure; enhancing soil aeration and improving water retention (Tarkalson *et al*., 2009; Scheewe, 2010), enhancing agronomic productivity in the long term, and encouraging the activity of micro-organisms (Lal, 2005; Matsumura *et al*., 2005; Rosmiza *et al*., 2015). Studies conducted at the Mekong Delta rice-growing region discovered that the use of straw compost together with the treatment of *Trichoderma sp*. fungus increased rice production by 5.91% and 7.92% during the humid and dry crop season respectively (Man *et al*., 2003).

A study conducted by Devasinghe *et al*. (2013) in Sri Lanka revealed that the use of rice straw as mulch material can increase the production of rice. The increase in rice yield can be measured by the increase in the number of rice panicles per unit area and the number of spikelets per panicle. The findings of the study also disclosed that the use of straw mulch can reduce the cost of pesticides and reduce the effects of pollution on the environment. It also improved the farmers' health due to the decrease in the use of chemical fertilizers and pesticides (Scheewe, 2010).

2.1.3. The Potential of Straw as Plant Growth Medium

The high nutrient content of straw makes it suitable as a growth medium for some edible mushroom species. Mushroom yield with the rice straw substrate can be 10.0% percent higher than wheat straw depending on the mushroom species and environmental conditions (Zheng *et al*., 2002). In the Hebei Province in China, straw utilization rose from 2.5% to 10.0% after three years of studies of a new culture medium for edible mushrooms. Results show that the quality and quantity of production were slightly increased. The cost of production was lowered by around 15-20% (Zheng *et al*., 2002).

3. METHODS

Quantitative and qualitative research design were used to demonstrate the beneficial effect of utilization of rice straw in farm activities. Farmers at the Muda Agricultural Development Authority (MADA) region were selected due to their ability in producing rice. In addition, the MADA region is the largest rice growing area in Malaysia with a contribution rate of nearly 40% of the country's rice supply. Besides, the challenges in managing straw are higher in this area compared to other rice bowl regions in Malaysia.

The purposive sampling method was used to determine the research subject based on certain characteristics. It involves (a) farmers who do not burn the straw, thus allowing other parties to collect straw in the paddy field and (b) farmers who re-use straw in the development of agricultural activities, such as compost and livestock feed. The number of farmers involved in the straw development project during these studies was over 267. This number is

constantly changing every harvest season due to weather conditions, logistics capability, time constraints and the willingness of farmers to participate in the straw collection. A snowball sampling method was subsequently used to obtain the size sample (Babbie, 2007) since MADA does not have comprehensive records of farmers involved in the straw collection project. The triangulation techniques (interviews, surveys and observations) were used to support, verify information, and enhance the evidence obtained from multiple sources (Othman, 2007).

The sample size representative of the farmers in this study was 160. It was determined based on the Krejcie and Morgan (1970) sample size determination table. Based on the size sample, 160 respondents were interviewed to analyze their level of knowledge on the potential of rice straw in agricultural development and its use in agricultural activities.

4. RESULTS AND DISCUSSION

There are various potential uses of straw in the agricultural activities such as livestock feed, compost, plant growth medium and animal bedding. The study found that all the respondents (100%) have knowledge of the potential of straw as livestock feed. A total of 155 respondents (96.9%) were aware of the potential of straw as compost, but only 89 respondents (55.6%) were aware of the use of straw as vermicompost. However, most farmers did not know about other potential uses of straw in agricultural development. This include its usage as a grass growth medium (97.5%), mulching materials (96.9%) and animal bedding (95.0%) (see Figure 1).

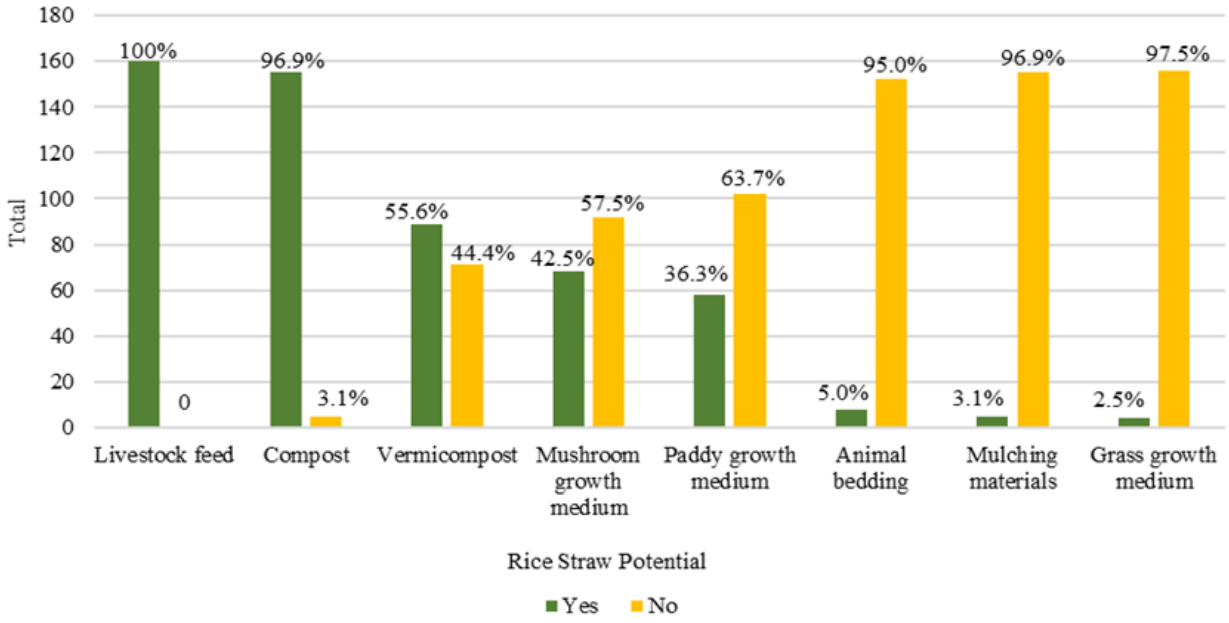

Figure-1. The farmers' knowledge towards rice straw potential in the agricultural sector.

Source: Fieldwork

Interviews revealed that the farmers' knowledge of the use of straw as livestock feed is derived from traditions. Traditionally, rice straw is considered as grass and a source of daily food for livestock. It is fed to cattle in barns or cattle on paddy fields after harvesting. Usually, it is given in the form of fresh or old straw.

Interviews revealed that the knowledge of straw's potential as compost, vermicompost, or as a growth medium for paddy and mushroom were often obtained from briefings and explanations given by agriculture extension officers and other farmers. The agriculture agency also gave a series of courses and demonstrations on the utilization of straw as compost and vermicompost. Farmers also obtained information about the various uses for straw from internet resources and general reading materials.

Although straw has many uses in agricultural activities, unfortunately only a small number of farmers in the 160 are taking advantage of its value and potential. A total of 45 respondents reuse straw as compost, while 37

respondents used it as livestock feed and only three respondents used it as growth medium as can be seen in Table 2.

Table-2. The reuse of straw in the agricultural activities.

The reuse of straw in the agricultural activities	Yes		No difference	
	Total	Percent (%)	Total	Percent (%)
i) Compost (n=45)				
Increased plant growth quality	42	93.3	3	6.7
Improved soil fertility	40	88.9	5	11.1
Increased yield	37	82.2	8	17.8
ii) Livestock feed (n=37)				
Saving the cost of purchasing livestock feed	37	100.0	-	-
Increased livestock growth rate	-	-	37	100.0
iii) Plant growth medium (n=3)				
Increased the rate of seedling germinations	3	100.0	-	-
Increased the quality of seedlings	3	100.0	-	-

Source: Fieldwork.

4.1. The Use of Rice Straw as Compost

Results showed that 45 respondents used straw as compost in paddy farming and horticulture as per Table 2.

4.1.1. The Quality of Plant Growth

A total of 42 respondents (93.3%) stated that the quality of plant growth is better with the use of straw compost. All the farmers declared that the use of compost will take relatively a long period to get good results, usually between three to four months. This is different from using chemical fertilizer where the results can be seen in a short period of time during the cultivation season itself. However, there are about three respondents (6.7%) that stated that there was no difference after using compost in planting as can be seen in Table 2. The interviews disclosed that the farmers have just used compost as fertilizer for their crops in one season. Thus, the effect of using compost on the quality of plant growth is not evident in the short term.

The interviews revealed that the quality of plant growth is better with the use of straw compost. This can be seen from the greener colour of leaves leaf, the wider size of leaves and the stronger plant stems. This proves that the use of straw compost makes plants' growth better. A stronger plant stem prevents the plants from harmful weather effects.

> "...I use rice straw compost for four seasons already. [Fewer] plants fall down because the stems are stronger. The leaves are wider and greener. They are different from the use of chemical fertilizers. But it takes a longer time to see the effect of using straw compost. Good things require some [patience] ..." (Farmer 13).
>
> "... The plants are [more] fresh and the quality of plant growth is very good..." (Farmer 21).
>
> "... I have used the rice straw compost for one season only. The soil quality and the results cannot be seen yet. But, if you look at my friends' field, who have been using straw compost for a long period in their field, you can see many differences such as the plant itself and the leaves are greener. They are just beautiful ... " (Farmer 37).

4.1.2. Improving the Quality of Soil Fertility

The findings revealed that 40 respondents (88.9%) admitted that the nutrient content of straw compost remains longer in the field than chemical fertilizers as per Table 2. This results in more fertile soil and the soil fertility level lasts longer. According to the respondents, some fields in the MADA area are slightly acidic. The interviews showed that acidic soils require liming for every planting season. This is to reduce the acidity of the soil and help

plants to grow. The use of straw compost can reduce the soil acidity and improve the quality of soil fertility. Indirectly, it can save time for soil liming work and the fertilization of crops.

In contrast, only five respondents (11.1%) stated that using straw compost has not shown any difference because they are new (one to two farming seasons) in using such compost on their paddy field as can be seen in Table 2. In fact, their field is located in the highly acidic area. The use of rice straw compost takes a relatively long time to reduce the high acidity level of the soil. Thus, the effects of using straw compost on highly acidic soil for these five farmers cannot be seen within the short term.

Interviews also found that the use of compost does not require specific measurements and does not damage the crops but makes the crops more fertile. This is in contrast with the use of chemical fertilizers which require specific measurements. Excessive usage of chemical fertilizer will also damage the crops.

> "... My paddy field is a bit acidic. So lime must always be put into the soil to make it more alkaline, thus it is more suitable for paddy growing. But since the use of straw compost, which is natural, it reduces the acidity of the soil. It remains longer in the soil. So, we no longer need to frequently put in the lime for every growing season. Now, the soil becomes more fertile soil…" (Farmer 18).
>
> "... Our planting area is slightly acidic compared to other places. According to MADA, the use of compost is good for reducing the acidity. I use quite a lot of paddy husk/rice straw compost on the field. It seems that the soil is more fertile, the crops are healthier and have better yields ..." (Farmer 29).
>
> "... This compost fertilizer has a lot of nutrients. If a lot is used, it does not harm the plants and the compost remains longer in the soil. No frequent fertilizing is needed as required by chemical fertilizers. Chemical fertilizers need specific measurement, under or over prescribed amount would affect the crop ..." (Farmer 36).

4.1.3. Increased in Yields Production

A total of 37 respondents (82.2%) stated that the rice yields are increased due to the use of straw compost (see Table 2). However, these results can only be achieved after using the compost for several rice growing seasons. This is because the organic fertilizer takes a longer time to show the effect compared to chemical fertilizers. Rice stalks appear to bear more rice grains, heavier and healthier than ever before.

> "... After several seasons of using straw compost, the yields are better..." (Farmer 6).
>
> "... If we look at the rice stalks, there are much more rice grains and they are heavier. In fact, rice production increased... "(Farmer 8).

4.2. The Use of Straw as Livestock Feed

4.2.1. Saving the Cost of Purchasing Livestock Feed

The study found that only 37 respondents reused the straw as livestock feed for cattle which they care for or raise for sale (see Table 2). The interviews showed that all respondents (100%) stated that it saved the cost of preparing animal food. Most of the food given to the cattle is straw and only a small amount of supplements is purchased from suppliers for the cattle. Furthermore, the straw is available free from the fields after harvesting season.

> "... Livestock food is getting more expensive. By feeding cattle with straw, it can reduce the costs but we have to mix it with other supplements because straw does not have a lot of protein …" (Farmer 5).
>
> "... The cost of buying food for the cattle is less because the cattle are fed with straw. After all, the straw can be found in the field for free …" (Farmer 10).

4.2.2. The Growth of Livestock

The results found that all farmers (100%) interviewed reported that straw is very filling as animal feed only. It does not help in terms of the livestock's growth. This is because straw has a relatively low protein content but is high in fibre. Thus, all farmers use supplements to aid the livestock growth and as added nutrients for the livestock and cattle.

"... I have to mix with other food because straw does have a lot of protein and it is filling as food only. You cannot make the cattle fatter … " (Farmer 3).

"... Rice straw is relatively low in protein but high in fibre. It is filling as animal feed only. We need to add other type of food or supplement to make the livestock healthier …" (Farmer 24).

4.3. The Use of Rice Straw as a Plant Growth Medium

4.3.1. The Quality of Seedling Germination

There are three respondents who use straw as a medium for the germination of rice seeds (see Table 2). These farmers still practice the transplanting methods compared to the rest who use the direct seeding method. The results revealed that they are very satisfied with the quality of the rice seeds' germination.

"... So far I am very satisfied with the use of compost as a medium of rice seedlings. Seed germination occurs quickly than before" (Farmer 1).

I used straw as a substrate for edible mushroom as well. A mushroom has grown well ... " (Farmer 1).

"... The use of straw as seedling allows the seeds to grow in a short period of time ..." (Farmer 2).

"... The seeds germinate quickly with the use of compost as a mean for planting ..." (Farmer 3).

4.3.2. Quality of Rice Seeds

All respondents said that the quality of rice seeds is better when using straw as a growth medium. The seedlings appear healthier, mature faster and seems stronger to be transferred to the field.

"... The use of straw as a means of germination is good. Paddy plants look more fertile and grow quicker ... " (Farmer 13).

"... Since the use of straw, the seeds grow faster, look more robust and fertile..." (Farmer 11).

Overall, utilization of straw in agricultural activities would increase the quality of plant growth, enhance soil quality and the fertility of crops, increase the yield of production, increase livestock's growth and reduce the cost of farm management. Thus, increasing straw-utilization on-field and off-field could increase the socioeconomic class and level of farmers and move them towards more sustainable agricultural systems.

5. CONCLUSION AND RECOMMENDATION

As the third engine of national economic growth in Malaysia, the agricultural sector should move towards managing agricultural residues that are biodegradable and could be new sources. The improvement and the strength of straw's commercial value in agro-industrial development is very important in contributing to the environmentally-friendly management. Farmers need to increase their knowledge of straw management to move towards more sustainable agricultural goals and to motivate farmers to participate more in added-value agri-business. However, the crucial challenges for the commercialization of straw is that it is widely abundant throughout Kedah. With there always being a bulk of it, farmers find it difficult to manage straw in effectively ways. It requires good facilities, such as transportation equipment and proper storage. Research and Development (R&D) also needs to be strengthened in improving the effectiveness of the use of straw and diversifying its existing potential. The strength of using straw in agricultural activities is expected to boost the capacity of rice sub-sector and move it to become more competitive in an environmentally-friendly management and enhance the socio-economic class and level of farmers.

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