Farmers' knowledge on potential uses of rice straw: An assessment in MADA and Sekinchan, Malaysia

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Abstract

Rice straw in Malaysia is presently disposed of mostly by open burning. This results in the release of various pollutants affecting the environment, weather and local communities. Yet, there are several potential uses for rice straw which can still be explored and developed to benefit Malaysia's rural economy. The present study involved 160 farmers in two of the largest granary areas of the Kedah's Muda Agricultural Development Authority (MADA) and the Selangor's Sekinchan Integrated Agricultural Development Area (IADA). An evaluation of the knowledge level among farmers and their methods relating to straw use was undertaken. As farmers are the main actors in rice production a high knowledge level about the potential economic benefit of straw use may encourage them to utilise this by-product more competitively while also adopting more ecologically sustainable agricultural practices. This research found that most farmers knew only some of the potential uses of the straw, namely as a source of animal feed, compost, vermicompost, nursery mats for seed germination, and paper making. Farmers acquired most of this information from other farmers who had realised the potentials through involvement in straw development projects. This points to the fact that more farmers could be motivated to get directly involved in the future development of straw projects presently conducted by agricultural agencies. Better information and extension services relating to commercial straw development and management could help further these economic as well as the environmental causes of straw development.

Keywords: agricultural residue, ecosystem, granary area, straw management, straw potential, sustainable agriculture

Introduction

When cereal crops are harvested, it is estimated that half of the process ends with agricultural waste or crop residue as straw. It is a non-edible product, often left in the field after harvesting (Chamhuri, 2005; Lal, 2005). The United States Department of Agriculture (USDA) estimates that the world rice production in 2013/14 will be 475.57 million tonnes, that could also represent an increase of 4.31 million tonnes from the previous year around the world (USDA, 2014). As a major producer and exporter of rice in the world, China reportedly produces around 204.28 millions tonnes of rice per year. This is followed by India (152.60 millions tonnes) and Indonesia (69.04 millions tonnes). China is the largest global producer of rice straw (FAO, 2014).

Typically, information on rice production is used to estimate the amount of straw derived. In California, based on collection operations in the form of straw bales, farmers estimate that the rice straw to yield ratio is 0.5:0.3, without regard to the straw left in the field which is on average about 10% (Summers et al., 2003). According to Binod (2010), the ratio of grain harvested and straw is 1:1.5 kg. This ratio would give around 650–975 million tons of rice straw per year globally. In Malaysia, the ratio of grain harvested to straw is 0.45:0.55 (MADA, 2010). Given the ratio of grain yield and straw is almost same, Muda Agricultural Development Authority (MADA) also use ratio 1:1 to estimate the amount of straw that will be obtained (MADA 2010). However, a measure of the ratio between grain yield with straw which is often used in the latest rice varieties of moderate height is 1:1 (total gross rice to straw) (Summers et al. 2003; MADA, 2010). The production of straw can be influenced by weather conditions, varieties of rice, grain yields and methods during planting, harvesting and straw collecting (Hrynchuk, 1998).

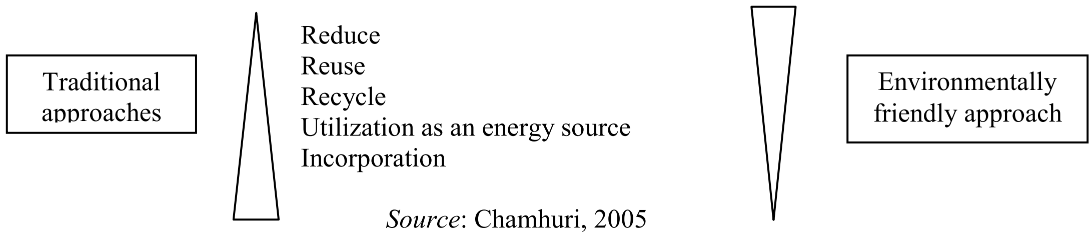
Traditionally, straw is managed through on-farm burning. It is left in the fields; stacked in a specific area; and used by households as a domestic uses for cooking and heating (Silalertruksa & Gheewala, 2013; MADA, 2010). The straw will be burned during the harvesting season as the cheapest, and probably easiest way to prepare the field for the next cultivation season. Straw burning is practised particularly where crop rotations do not allow sufficient time for decomposing; progressing ploughed-in straw (Silalertruksa & Gheewala, 2013; MADA, 2010) and due to lack of cost-effective treatment approaches (Qian, 2014). In temperate countries, the practice of ploughing straw directly or after using it as bedding returns most of the nitrogen to the soil, but also reportedly wastes all the potential energy (Jackson, 2012).

Generally, and traditionally, straw burning is done to eliminate sources of insect pests, rat infestation and to prevent rice diseases. This is because the paddy is continuously worked on the farm, which does not eliminate the life cycle of insects and the disease. In fact, the burning of straw also facilitates ploughing and leveling the ground which saves time for land management for the next crop season (Silalertruksa & Gheewala, 2013; Rosmiza, 2012; MADA, 2010). A limited period for field management also encourages the burning of straw in the field after harvesting (Bridhikitti & Kanokkanjana, 2009).

Rice paddy contributes to the emission of greenhouse gases (GHGs) such as carbon dioxide, methane and nitrous oxide (Bhattacharyya, 2012). Burning straw can also cause air pollution such as haze, by producing on estimated 13 tons per hectare of smoke containing carbon dioxide. Burning a ton of straw will reportedly produce 3 kg of particulate matter, 60 kg of carbon monoxide, 1460 kg of carbon dioxide, 199 kg of dust and 2 kg of sulphur dioxide (Indian Agricultural Research Institute, 2012; Gupta et al., 2004). These gases play an important role in affecting the atmosphere and environment that lead to global climate change (Gupta et al., 2004). In fact, the particles can also easily invade the lungs causing respiratory disease, especially for children and patients with asthma. Furthermore, incomplete combustion produces carbon monoxide and carcinogenic hydrocarbons which could perhaps cause cancer (Henderick & Williams, 2000). Straw left in the field can also led to environmental problems with the release of methane emission which is the major contributor to the greenhouse gas emissions, sharing around 80% of the total GHG emissions from the cultivation stage (Silalertruksa & Gheewala, 2013; Mandel et al., 2004; Dobermann & Fairhurst, 2002).

Almost all the nutrient content present in the straw be lost of more than 80% of nitrogen, 25% of phosphorus, 20-21% of potassium and 40-60% of sulphur burned (Mandal et al., 2004; Dobermann & Fairhurst, 2002). These will have a significant impact on the level of soil fertility. The burning of straw in the field has an effect of heat on the soil surface to a depth more than 1cm, with a recorded temperature of over 33.8°C- 42.2°C (Gupta et al., 2004). In addition, it can also block the ditches and canals if dumped near an irrigation system (Sariam, 1996).

To overcome the open burning of agricultural waste or crop residue (straw), more environmentally friendly waste management approach have been explored and introduced, including zero waste and zero burning. These approaches emphasize minimal waste; re-use and recycling of farm products; composting; utilization as an energy source; or re-use for landscaping etc. (Figure 1) (Chamhuri, 2005). The feasibility of using crop residue for on-site farm utilization for fodder, fibre, industrial raw material, biofuel, water quality improvement and sedimentation control; and off-site for soil quality enhancement; soil and water conservation and biodiversity improvement as possible (Lal, 2005).



Source: Chamhuri, 2005

Figure 1. *Environmentally friendly waste management approach*

The large amount of straw is a big loss if that residue is not being better utilised and exploited. There are also various potential straw uses that can be developed. In agriculture itself (upstream), straw can be exploited as a compost, plant growth medium, animal feed and animal bedding in livestock area. Straw can also be used in creating industrial chain (downstream) with (i) the manufacturing sector including the production of paper, food packaging and activated carbon materials; (ii) the construction sector including construction materials and erosion control and (iii) the renewable energy source that produces biofuel (ethanol), electricity and biogas (Table 1).

Table 1. Straw potential in industrial chain (downstream and upstream) within agricultural sector and others sector

Agricultural sector	Manufacturing industries	Construction sector	Renewable energy
Compost	Paper making	Building material	Biofuel
Vermicompost	Food packaging	Thermal insulation	(ethanol)
Nursery mats	Activated carbon materials	Erosion control	Electricity
Mulching	Pyroligneous acid	Grass growth medium	Biogas
Mushroom growth medium		Land reclamation	(domestic uses)
Livestock feed			
Animal bedding			
Thatching			

Source: Park et al., 2014; Qian et al., 2014; Department of Science, Technology and Environment, 2013; Kanokkanjana & Garivait, 2013; Nguyen et al., 2013; Thapat & Gheewala, 2013; Delivand et al., 2012; Indian Agricultural Research Institute, 2012; Li et al., 2012; Liu et al., 2010; Lal, 2005; Devendra & Sevilla, 2002; MADA, 2004.

As a renewable natural resource, straw has huge potential to be developed further as an alternative source, also perhaps to replace fossil-fuel resources that are dwindling; to counter rising fossil fuel prices; energy security; and reduced threat to the development of climate change (Park et al., 2014; Li et al., 2012; Nguyen et al., 2013; Silalertruksa & Gheewala, 2013; Kopetz, 2007; Gadde et al., 2009; Shyam, 2002). Of particular importance perhaps, is that straw waste could help reduce risks of overdependence on fossil-fuel imports, and could may be enhance national security and international stability. The other potential impacts through further straw development are potential increasing of local standards of living; stimulating the regional economy through greater local investment; more social cohesion and stability; security of supply diversification; increasing agricultural productivity; contributions to social well-being; creating new employment; reducing pollution; and preventing the risk of road accidents when straw is burned near the road (Delivand et al., 2012).

In Japan, Korea and also several countries with highly populated rural area, and sometimes high rates of poverty, they have also developed biofuel, electricity energy and biogas using agricultural residues. This can be seen in the use of straw as a source of electricity in China of around 53.6%; biogas in India (28.0%); fuel in South Korea (20.0%) and Taiwan (5.1%) (Gadde et al. 2009; Su, 2009; Matsumura et al. 2005; Devendra & Sevilla, 2002; Devendra, 1989). It may be even more now, since these earlier reports.

In China, the major straw from cereals crop produced are from rice, wheat and corn. As the most efficient biomass resource in China, straw has been focused on for biomass energy and rural development impact. Straw reportedly contributes 50-60% of the total energy amount in biomass energy (Li et al., 2012). Straw biomass is one of a renewable energy resources. It can be converted into energy and chemical feedstock. Various mechanical, biological and thermo-chemical conversion technologies have been developed and applied in industry to produce different types of energy, fuel and chemical products. The thermo-chemical conversion includes pyrolysis, gasification and combustion (Park et al., 2014). Straw has now been largely using for electricity generation in China. It could help reduce coal-mine accidents, resource waste and environmental pollution because of the high dependence of electricity generation on coal (Tao & Li, 2007). It could also grow to be an effective and practical choice to guarantee the more sustainable development of China because of its potential for renewability (Liu et al., 2010). In the rural areas, however, straw is usually used in traditional ways such as for animal feed, fertilizer, paper making and domestic uses (Li et al., 2012; Liu et al., 2010).

The nutrient content in rice straw is presented in Table 2 (Ismail et al., 2013). This makes the straw suitable for developing as compost to improve soil fertility. In dry weight, the moisture content would loss around 14%-16%. Straw incorporated would built up soil carbon as well as soil nitrogen returning valuable nutrients to the ecosystem (Nguyen et al., 2013).

Table 2. Nutrient content in rice straw

Nutrient content	Percent (%)	Nutrient content	Percent (%)
Nitrogen (N)	0.65	Magnesium (Mg)	0.20
Phosphorus (P)	0.10	Calcium (C)	0.30
Potassium (K)	1.40	Iron (Fe)	0.035
Zink (Zn)	0.003	Manganese (Mn)	0.045
Sulphur (S)	0.075	Copper (Cu)	0.0003
Silicon (Si)	5.5	Boron (B)	0.0010

Source: Ismail et al., 2013

According to Lal (2005), soil quality will improve by returning crop residue into soil through its potential influence on reducing risks of soil erosion; stabilizing soil structure and improving tilth; reducing soil bulk density; storing or recycling nutrients; improving water retention and transmission properties; providing energy for microbial processes; increasing cation exchange capacity and enhancing agronomic productivity. Composting is also very suitable for growing fruit plants and vegetables and general horticulture-use (Rosmiza, 2012). Around 61.5% of rice straw in Japan is ploughed into the field for general organic compounds to also encourage the activity of micro-organisms (Matsumura et al., 2005). Several countries such as Taiwan of up to 56.9% of the rice harvest and South Korea (46.0%) have previously successfully developed and utilised rice straw as a compost (Table 3) (Devendra & Sevilla, 2002).

Straw as a livestock feed can be given directly to some animals without treatment (Devendra, 1989). This makes it easier for cattle to be released on paddy fields after harvesting (Rosmiza, 2012). In Asia, the maximum intake of rice straw per 100 kg liveweight is around 1.0–1.2 kg. In Southeast Asia, the average intake of straw by swamp buffalo and cattle (determined by using adult liveweights of 350 and 200 kg) is 1.0 kg of rice straw per 100 kg liveweight (Devendra & Seville, 2002). Several countries are well-developed in utilising straw as livestock feed (Table 3) (Gadde et al., 2009; Su, 2009; Matsumura et al., 2005; Devendra & Sevilla, 2002; Devendra, 1989). In Japan, using straw as an animal bedding is also possible when the rice producer and cattle breeder are located nearby each other, and the straw available in sufficient amounts (Matsumura et al., 2005).

Table 3. Rice straw utilization in Asia countries

Country	Rice straw utilization	Percent (%)
Bangladesh	Livestock feed, compost, biogas	74.4
Korea	Compost	46.0
	Biofuel	20.0
	Livestock feed	15.0
Thailand	Livestock feed	13.0
	Compost	5.0
	Raw material (sell)	1.5
	Biofuel	0.2
	Others activities	0.3
China	Rural energy (electricity)	53.6
	Livestock feed	28.0
	Fertilizer	15.0
	Paper making	2.1
	Reused on the farm and collected for other purposes	16.2
Japan	Livestock feed	11.6
	Compost	10.1
	Animal bedding	6.5
	Combustion	4.6
	Erosion control	4.2
	Mulching	4.0
	Incinerator	3.1
	Handicraft	1.3
	Processed	1.1
	Other activities	0.3
India	Biogas	28.0
	Other activities (livestock feed and roof)	49.0
Taiwan	Compos	56.9
	Livestock feed	11.0
	Biofuel	5.1
	Other activities	22.1
Philippines	Livestock feed, mulching, mushroom growth medium	5.0
Malaysia	Livestock feed, compos, erosion control, mushroom growth medium, paper making	1.0

Source: Devendra, 1989; Gadde et al., 2009; MADA, 2010; Matsumura et al., 2005; Su, 2009; Liu et al., 2010; Devendra & Sevilla, 2002; Li et al., 2012

Straw potentially has a high nutrient value potential and could be more economically beneficial. It is a great loss if this agricultural residue is wasted. Agricultural byproducts development are also capable of driving the development of agro-based industry potentially, towards greater economic competitiveness. In an economic sector that demands highly competitive products, and increasingly biotechnology development, the potential of straw development could be envisioned to drive the country towards creating a stronger industrial chain. Moreover, it is a new strategy in the further development of the agricultural sector, which can also create additional opportunities for rural economy development in generating farmers income; creating new jobs from existing resources particularly in the production and marketing; more employment opportunities for youths; women and housewives; generating investment by the establishment of possible new industries and expansion of Small and Medium Enterprises (SMEs); the existence of comparative advantages of the product and leakage reduction in the economic process as a substitute for exports and imports (Delivand et al., 2012; Chamhuri, 2005; Pazim, 1997). Furthermore, as mentioned, it could also help improve the environmental effect from straw open-burning after harvesting. (Silalertruksa & Gheewala, 2013; Chamhuri, 2005; Shyam, 2002).

The accessibility of information to farmers is important because they are the principal stakeholders and contributors of the rice paddy sub-sector. The best method of enhancing the utilization of straw is creating policies to control straw open-burning, and to encourage participation from farmers and local communities (Rosmiza, 2012). Hopefully, straw industries can expand more widely when farmers learn more of the opportunities, via continuous information through demontrations in the field, workshop, training, farm visits and open discussion, and perhaps incentives. Farmers also need to be exposed to information about the adverse effects of open-burning and the economic potential of straw in the economy. They also have to change more from their traditional practises to environmental farm management (Bridhikitti & Kanokkanjana, 2009; Gheewala, 2009; Roy & Rangnekar, 2006).

Rice production in Malaysia is encouraged and supported by the climate and types of soil which are suitable for the crop. This situation is aided by good irrigation systems often and the use of quality fertilisers. The National Agro-food Policy (2011-2020) has set a rice self-sufficiency level at 71.4% (2011), 71.5% (2015) and 69.8% (2020) (Department of Agriculture, 2013). Meeting this needs and maintaining eight granary areas (389 000 hectares) with a four new granary area (19 000 hectares) in Kota Belud (Sabah); Batang Lupar (Sarawak); Rompin dan Pekan (Pahang) will increase the straw supplies after the harvesting season (Bernama Media, 2012). In 2000, total production straw for all paddy cultivation seasons (of two periods) in Malaysia was 2, 616 660 tonnes. The amount increased to 3, 012 571 tonnes (2010) and 3, 177 022 tonnes in 2012 (Table 4) (Department of Agriculture, 2013).

Table 4. Total production of paddy and straw for all cultivation season in Malaysia, 2000-2012

Year	Planted area (hectares)	Paddy production (tonnes)	*Straw production (tonnes)
2000	698 702	2, 140 904	2,616 660
2001	673 634	2, 094 995	2,560 549
2002	678 544	2, 197 351	2,685 651
2003	671 820	2, 257 037	2,758 600
2004	676 310	2, 291 353	2,800 542
2005	666 781	2, 314 378	2,828 684
2005	676 034	2, 187 519	2,673 634
2007	676 111	2, 375 604	2,903 516
2008	656 602	2, 353 032	2,875 928
2009	674 928	2, 511 043	3,069 052
2010	677 884	2, 464 831	3,012 571
2011	687 940	2, 578 519	3,151 523
2012	684 545	2, 599 382	3,177 022

* Note: Ratio grain yield to straw is 0.45:0.55 (MADA, 2010)
Source: Department of Agriculture, 2013.

MADA as the rice bowl of Malaysia (the largest area for rice cultivation), contributes about 40% of the country's rice supply (MADA, 2014). However, around 1.0% of rice straw has diverse various uses including animal feed, compost, paper products and mushroom growth medium (MADA, 2014). The rest of straw is burned in the open. It should be contributing more to the socio-economic development of farmers and the agricultural region, probably. Based on the MADA planted area (96 558 hectares), the estimated amount of straw produced from harvesting activities is 400 000 tonnes per season. However, only a smaller amount can be collected of around 4000-5000 tonnes (Zulkifli, 2013). During 2013, the straw that has been collected is 3000 tonnes by using 10 units baler machine from four `*Pertubuhan*

Peladang Kawasan' (PPK) (District Farmer's Organisation) (MADA, 2014). It clearly shows that a lot of straw resources have not been fully utilized. Table 5 indicates the production of straw (in baless), in the project by the MADA agency. The availability of collecting straw is constantly changing however, according to the weather, logistics, time restriction and participation of farmers but not considerably (MADA, 2014).

Table 5. Production of straw project in the MADA region, 2008-2013

Location	Straw project production (bale)					
	2008	2009	2010	2011	2012	2013
PPK B-II, Sanglang	1,722	3,381	2,133	4,027	4,772	3,320
PPK E-III, Kokbah	892	315	856	1,107	783	1,585
PPK B-IV, Pengkalan Kundur	-	-	-	310	263	510
PPK F-IV, Sungai Limau	1,158	1,244	1,290	2,409	1,278	1,271
Total	3,772	4,940	4,279	7,853	7,096	6,686

Source: MADA, 2014

As the proposed third engine of economic growth in Malaysia, 'New Agriculture' should be extended to analyze all the potential of agriculture by-products through appropriate biotechnology. It should involve modern technology, entrepreneurial farmers and a skilled workforce (Kementerian Pertanian Malaysia, 1998). This is in accordance with government policy to encourage agricultural activities, and will be managed in a more sustainable manner with greater emphasis on (i) the conservation of biological diversity; (ii) environmental protection; (iii) the use of agricultural byproducts; (iv) the exploitation of green technology as a source of growth; (v) generating employment across sectors and (vi) using natural resources to maximize the potential of renewable energy (Kementerian Pertanian Malaysia, 1998).

This study attempts to identify the level knowledge of farmers on diversification of straw potential uses that can be further developed in Malaysia. This is important, because without the more understanding of potential, straw can often be considered simply as an agricultural waste, just to be cleared from fields for the next cultivation season. The study also attempted to discover how the farmers obtain information on straw potential.

Research methodology

The study compared the level of understanding and knowledge towards straw potential among the farmers in two major granary areas in Malaysia which is MADA, Kedah and Sekinchan in Integrated Agricultural Development Area (IADA) North-West Selangor. As these are two major rice bowl of Malaysia, straw production will also increase with the various programmes for increasing yield production.

Evaluating farmers knowledge towards rice straw potential is the primary objective, as they are the main determinants of the production of paddy and straw. Farmers will have particular impact on burning straw decisions also in fields. However, if other straw potential was developed it would create additional income for farmers. In addition, it could determine the straw management in a more environmentally acceptable way to be implemented in both the agricultural regions studied and Malaysia as a whole.

This study utilises a combination of quantitative and qualitative approaches. The farmer population involved in the straw development project during this study in the MADA region was over 267 and 300 farmers in Sekinchan. Based on the determination of sample size, 160 respondents were interviewed. This number is always changed in every harvesting season, depending the current situation such as climate, logistics capabilities, time constraints and willingness of the farmers to participate in the project.

A purposive sampling method is used to determine the subjects based on certain characteristics (Israel, 1992). It involves farmers who do not burn straw and allow certain parties to collect straw on the field, and farmers who use the straw. The triangulation techniques (interviews, surveys and observations) are used to support and enhance the evidence obtained from multiple sources (Othman, 2007). This technique is also able to verify information obtained through interviews and field observations.

Results and discussion

An evaluation of farmer's knowledge towards rice straw potential

The study found, overall, that farmers had little broad knowledge of straw potential. The majority of them know only of some potential straw uses which can be exploited such as animal feed, compost, vermicompost, crafts, nursery mats and paper making. However, there are about 19 potential straw uses identified elsewhere. The interviews revealed that almost all farmers in the MADA region and Sekinchan know about straw use potential from projects that are being implemented by agriculture agencies in their regions. In this case, farmers are directly involved in straw project development that have been planned for them and from which they are already benefitting.

Straw potential in development of agricultural sector

1. Livestock feed

As seen on Table 6, all respondents (100%) in the MADA region and about 133 respondents (83.1%) in Sekinchan know that straw can be used as livestock feed. This confirms the traditional use of rice straw in Malaysia as food for cattle. From the interviews it was also found that straw is also given as an additional supplement because straw contains high fiber, but less mineral content, for growing cattle.

2. Compost and vermicompost

Past studies have shown that straw has a potential in improving soil fertility (Rosmiza, 2012; Lal, 2005; Matsumura, 2005; Sariam, 1996). It depends on how straw has been exploited by incorporating into the soil or processed into compost. The study found a total of 155 respondents (96.9%) in the MADA region and 129 respondents (80.6%) in Sekinchan know straw can be used as compost (Table 6).

Most of the farmers in the MADA region were involved in collecting straw to be used in compost and vermicompost project. This project had been developed by MADA and the Department of Environment, Kedah (MADA, 2014). In addition, there are also a number of farmers producing a compost for their own use, and for selling in local market (Rosmiza, 2013).

This contrasts with straw-use development as compost in Sekinchan. Farmers have been involved in Systems of Rice Intensification (SRI) that is widely practiced in Indonesia, India, China and Afghanistan (Norazimah, 2011). Interviews found that most of the respondents in Sekinchan incorporated straw into the field to restore the nutrients that are present in the straw. This method is used to improve soil fertility. Straw on the field would be further slashed into pieces using a flail drawn by tractors. Then, if considered suitable, the straw would treated using various types of extract plant and natural materials as a mediums such as bamboo, pumpkin, banana, coconut husk, cocoa shell, bone etc (Norazimah, 2011; MOA, 2012). Straw could be treated with indigenous microorganism 2 (IMO-2) using local microorganism (MOL) rice and fermented plant juice (FPJ) using MOL kangkung (MOA, 2012). These materials can sprayed on straw in the field. Then, the straw will be ploughed into the moist soil. Microbes will reportedly respond more quickly to break down the straw in the warm moist soil. Within three weeks, the straw will almost completely decay overall (Norazimah, 2011; MOA, 2012). The field is then ready for the next cultivation season.

A total of 71 respondents (44.4%) in the MADA region and 156 respondents (97.5%) in Sekinchan did not know that straw can also be used potentially as vermicompost. Vermicompost is straw compost using worms as a medium. It produced raw-vermicompost and worm-tea (Zulkifli, 2013). Interviews show that more than half of the respondents (55.6%) in the MADA region, however, know the potential through the ongoing MADA vermicompost project (Table 6).

3. Plant growth medium

Nutrients in straw allows it to be used also as a medium for mushroom production, seed germination and also grass growing. The survey shows that a total of 68 respondents (42.5%) in the MADA region know that straw can be used as mushroom growing medium, while only 8 respondents (5.0%) in Sekinchan knowing about that potential. This contrasts with all respondents (100%) in Sekinchan knowing the potential of straw as a nursery mat for seed germination. Interviews revealed that farmers are aware of this potential, because there is a factory nearby their farms. The factory is using straw as a medium for seed germination. In fact, the factory also supplies paddy seedlings to the farmers (Table 6).

A total of 102 respondents (63.7%) in the MADA region do not know that straw potential use as a nursery mat for seed germination (Table 6). This is because most of the farmers in the MADA region use a direct seedling method for cultivation, rather than transplant method. Therefore, straw usage as a paddy seed germination medium is not practiced among the farmers in the MADA region. The majority of respondents in both regions, 156 respondents (97.5%) in the MADA region and 147 respondents (91.9%) in Sekinchan are not aware of straw potential as a grass growth medium. This shows that farmers still lack sufficient knowledge of potential straw uses (Table 6).

4. Animal bedding

The results indicate that most of the respondents, 95.0% and 97.5% in the MADA and Sekinchan do not know that straw can be used as animal bedding for ruminants (Table 6). In fact, it's also become a bedding material for crocodiles. The usage of straw as crocodile's bedding has been practised at the Crocodile Farm in Langkawi (MADA, 2010).

5. Mulching

Straw also can be used as a mulching material. It has an important role in hot and dry climates because it maintains soil moisture through reducing evaporation. Straw also has the capability of influencing pest populations in the field such as snails and to prevent weed growth. It can also contribute as an organic fertilizer. These advantages should be used for vegetables, fruits and horticulture more generally. This can increase the value-added of straw and create additional income for farmers. Unfortunately, only 5 respondents (3.1%) in MADA region and 14 respondents (8.8%) in Sekinchan know the straw potential as a mulching material (Table 6).

Straw potential in the development of manufacturing industries

1. Paper making (paper and craft)

In the paper making and craft industry, the texture of straw is more fine and attractive compared to the other local materials such as banana's trunk, kantan's trunk, mengkerai's trunk and pandan leaves (Rosmiza, 2012). This ensures straw also has a place in paper making and craft projects lead by MADA agencies. Thus, a total of 130 respondents (81.3%) and 97 respondents (60.6%) in the MADA region are aware of the straw potential in paper making and craft. Only 50 respondents (31.3%) and 3 respondents (1.9%) in Sekinchan, however know that straw has the potential to be developed as a paper and related crafts. Interviews suggested that the limited knowledge of this potential in Sekinchan may due to their agricultural agencies not promoting straw for such uses (Table 6).

2. Other potentials

However, none of the respondents knew that straw can be developed as a food packaging materials; activated carbon materials and pyroligneous acid. Developing straw as a food packaging material could replace the use of polystyrene, that can reportedly adversely affect human health , and contribute perhaps to cancers (Utusan Malaysia, 2012). In addition, it also threatens the environment, as it would take around hundred of years to decompose and may also turn into toxic materials (Utusan Malaysia, 2012). Activated carbon material and pyroligneous acid is usually used to clear up contaminated drainage or irrigation (Table 6) (MADA, 2004).

Straw potential in development of construction sector

Only a small number of respondents know the capabilities of straw in supporting construction development. Table 1 indicates only four respondents (2.5%) in the MADA region were aware that straw can be developed for soil erosion control, and two respondents (1.3%) as a building material. Meanwhile, all respondents (100.0%) asked did not know its potential of land reclamation. However, there is a small farmer in the Sekinchan who did know the straw potential as soil erosion control (10.0%), building materials (7.5%) and land reclamation (3.8%) (Table 6).

Straw potential in renewable energy

Table 6. The knowledge level of farmers of straw potential-uses

Straw potential	MADA region, Kedah				Sekinchan, Selangor			
	Yes		No		Yes		No	
	Number	%	Number	%	Number	%	Number	%
Agricultural Sector								
Livestock feed	160	100	-	-	133	83.1	27	16.9
Compost	155	96.9	5	3.1	129	80.6	31	19.4
Vermicompost	89	55.6	71	44.4	4	2.5	156	97.5
Mushroom growth medium	68	42.5	92	57.5	8	5.0	152	95.0
Nursery mat	58	36.3	102	63.7	160	100.0	-	-
Animal bedding	8	5.0	152	95.0	4	2.5	156	97.5
Mulching	5	3.1	155	96.9	14	8.8	146	91.3
Grass growth medium	4	2.5	156	97.5	13	8.1	147	91.9
Manufacturing industries								
Craft	130	81.3	30	18.7	50	31.3	110	68.8
Paper making	97	60.6	63	39.4	3	1.9	157	98.1
Food packaging	-	-	160	100.0	-	-	160	100.0
Activated carbon material	-	-	160	100.0	-	-	160	100.0
Pyroligneous acid	-	-	160	100.0	-	-	160	100.0
Construction sector	4	2.5	156	97.5	16	10.0	144	90.0
Erosion control	2	1.3	158	98.7	12	7.5	148	92.5
Building material	-	-	160	100.0	6	3.8	154	96.3
Land reclamation								
Renewable energy	16	10.0	144	90.0	-	-	160	100.0
Biofuel (ethanol)	10	6.1	150	93.7	-	-	160	100.0
Electricity	2	1.3	158	98.7	-	-	160	100.0
Biogas								

Several countries including China, India and Bangladesh have been successfully supplying energy and electricity by using straw. This is particularly due to the insufficient supply of electricity particularly in rural areas. Similarly, straw also can be developed as an alternative energy source such as biofuel (ethanol) and biogas.

Unfortunately, the survey result indicates only a small number of respondents in the study area were aware of straw potential used as an alternative energy source. Only 16 respondents (10.0%) in the MADA region know that straw can be potentially used as biofuel, electricity (6.3%) and biogas (1.3%). Meanwhile all respondents (100%) in Sekinchan did not know that straw has the potential to be developed as a renewable energy source (Table 6).

Methods of farmers acquiring information on straw potential

The respondents get information or knowledge related to straw potential through various means. Some of them get the information from the other farmers; briefings by agriculture officer (MADA agency and DOA, Sekinchan); printed media and electronic media. A total of 79 respondents (49.4%) in MADA and 68 respondents (42.5%) in Sekinchan have the information from farmers in their neighborhood. Interviews also revealed that discussions among farmers in their neighborhood in sharing the relevant information on the advantages of straw development project were useful.

Meanwhile, 66 respondents (41.3%) in the MADA region and 54 respondents (33.8%) in Sekinchan have gained information from entension officers. This situation shows that many farmers in both agricultural regions do not hear of potential straw uses through agricultural agencies. Unaccessability to related information will affect agriculture development as a whole. Farmers should be given more access to comprehensive information on all aspects of agricultural development that could contribute to increasing the value-added of their agricultural products.

Results showed that 20 respondents (12.5%) in the MADA region and 15 respondents (9.4%) in Sekinchan get information on straw potential through the printed media such as brochures, pamphlets or general reading materials (newspapers and magazines). Electronic media (the internet and television) also play an important role in disseminating the latest information on agricultural development. However, only a few farmers (10.6%) in MADA region and 24 respondents (15.0%) in Sekinchan acquire relevant information through internet access and television (Table 7).

Table 7. Method in getting information of straw potential

Method of information	MADA Region, Kedah		Sekinchan, Selangor	
	Yes	No	Yes	No
Local famers	79 (49.4%)	81(50.6%)	68 (42.5%)	92 (57.5%)
Extension officers	66 (41.3%)	94 (58.7%)	54 (33.8%)	106 (66.2%)
Printed media	20 (12.5%)	140 (87.5%)	15 (9.4%)	145 (90.6%)
Electronic media	17 (10.6%)	143 (89.4%)	24 (15.0%)	136 (85.0%)

Overall, results indicate that farmers had a low level of knowledge towards the range of possible rice straw-uses. They often had a lack of information on how straw development could offer more benefits to their further socio-economic development. This seems to be due to a weakness of agricultural extension delivery systems and information technology, but may also reflect reluctance of many farmers to get involved. The present study did not often explore costs and profitability of other straw uses. Thus, only a small percentage of farmers seem to get the benefits from straw development projects.

Conclusion

As a developing country, some say 'newly-industrialising country' with agriculture considered the third engine of national economic growth in Malaysia, economic development could be further stimulated by new products and processes using locally-produced raw materials. Various straw-uses are considered to be a new source of economic development in Malaysia. This may also have to be done in the interest of greater environmental protection; improving rural development as well as more direct benefits for the farming community.

Farmers should perhaps support zero burning in rice field management towards more sustainable agricultural goals. Farmers should get more information about straw potential and how to manage it more effectively. The potential economic benefits could be a great motivation for them to participate more in this added-value agri-business.

Government and agricultural agencies need to provide a more training for farmers and extension officers; to also provide competent and easily accessible advisory services; providing necessary logistics (storage and baler machine); supporting research and development; and providing more capital support. MADA and Sekinchan as the two largest of rice bowls in Malaysia, with the availability of existing agricultural infrastructures, who could ensure that straw development is able to lift the agricultural sector towards greater competitiveness. Straw development downstream and upstream, and its linkages with other economic sectors (manufacturing and construction) and also as an alternative energy sources, could make the paddy sub-sector much more competitive. Furthermore, these agricultural by-products would strengthen the ecosystem as they could lead to more ecologically sustainable agricultural management.

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