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Traditional knowledge system on paddy straw management in North-East India

Thingujam Bidyalakshmi[a,*,!], Khwairakpam Bembem[a,@], K Narsaiah[a,#], Hijam Jiten Singh[b,$] & H Dayananda Singh[b,^]

[a]ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana 141 004, Punjab

[b]ICAR-Research Complex for NEH Region, Umiam 793 103, Meghalaya

E-mail: [!]Bidyalakshmi.Devi@icar.gov.in; [@]bembemkhwai@gmail.com, khwairakpam.bembem@icar.gov.in nar; [#]K.Narsaiah@icar.gov.in, knarsan@gmail.com; [$]hijam_jiten@yahoo.co.in; [^]dayamangang@gmail.com

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Burning of paddy straw in the field is a national issue nowadays. Many researches have been taken up for efficient utilization of paddy straw at national and international level. But the use of paddy straw for various applications is known since ancient days. The application of paddy straw varies from region to region. Therefore, an attempt has been made to collect information on the traditional uses of paddy straw and its management in the Northeastern states of India particularly Manipur. The information has been collected through review of literature and interaction with the villagers. The study revealed that the people of this region used paddy straw for different purposes such as thatching, wall construction, cattle feed, animal bedding, fuel, mulching, mushroom cultivation, handicraft products, extraction of substrate from straw ash and preparation of fermented beverages. This traditional knowledge on the utilization of paddy straw can provide an idea for scientific exploration for better and efficient uses in various fields.

Keywords: Feed, Handicraft products, Indegineous, Mulching, Straw ash, Thatching

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Rice is the staple food and major crop cultivated in the Northeastern (NE) regions of India. The production of rice in the NE regions is 8.96 lakh tonnes in 2019-20[1]. Paddy straw is a by-product produced while harvesting paddy. Ratio of straw to paddy ranges from 0.7-1.4 depending on the variety and growth[2]. In NE India, especially in Assam, around 51.5 thousand tonnes of rice straw are produced every year[3]. Unlike Northern states of India like Punjab, Haryana, Uttar Pradesh, paddy straws are not burnt in the fields probably due to less mechanized systems of agriculture and small landholding of the farmers in the NE states. Rather paddy straw is used for different applications. The absence of burning of paddy straw in the field and its uses for other purposes such as animal feed, thatching, mushroom productions, fuel, etc. has also been reported in neighbouring states like West Bengal[4]. However, the burning of the straw in NE regions has been reported for the last two decades, with the popularization of mechanized farming in the region[5]. This is also evident from the literature reported by a previous study[6]. The authors reported that the use of threshers cut the rice straw into pieces that make it unsuitable for further use except burning at the field. But the application of paddy straw for different purposes is well known since ancient times in the NE regions.

The method of threshing affects quality of straw. Earlier paddy was harvested manually by hand beating, trampling or using threshing rack, stick and pedal thresher and the straws were collected and stored at home for further uses[7]. Straw is traditionally stored in villages in circular or rectangular stacks built in open air over a platform made of indigenous materials like bamboo, wood and jute-sticks[8]. Usually, straws are bound in bundles having approx. 5-7 kg after collecting from the field. The cost of the straw bundle is Rs. 10-20/- depending on the size. The bound bundles are placed one above the other in an organized manner to form a heap and stored for further uses (Fig. 1). Paddy straw has social, cultural, and economic importance for the people of the NE regions of India. One study[9] reported that a large portion of the rice straw produced were burned (69.75%), some portion were used for animal feeds (8.25%), incorporated in soil (7.50%), used for thatching of animal shed and bedding of livestock

*Corresponding author

Fig. 1 — Piling and storage of paddy straw bundle into a heap. [Photo credit: The pictures were taken from the Andro Village, Imphal East District, Manipur]

(6%), used as mulch materials (5.75%) and for compost making (2.75%).

Methodology

The knowledge on the uses of paddy straw from NE India was collected through a mixed method which included a systematic search plan of publications (online electronic search and offline search) as well as personal interviews/focus group discussion of some selected villagers. The online literature search was performed via Google Scholar, Science Direct and Scopus using combinations of the keywords or phrases: "paddy straw in NE India", "crop residue management", etc. for searching research articles, proceedings, newsletter, reports etc. The offline search was also performed for relevant documents in proceedings of workshops, seminars, and conferences. The inclusion/exclusion criteria of the available literature search was based on year of publication, full text availability, duplicity and relevancy. The present study covered publications during the last 40 years. The screened articles/reports were studied and analysed thoroughly and then presented under different heads in the following sections.

For personal interviews/focus group discussions, two districts (Imphal-East and Imphal-West) from Manipur were purposively selected based on area of paddy cultivation, straw management practices being followed and proximity. Paddy farmers/elderly villagers were then selected for the present study following simple random sampling. A total of 20 (10 males + 10 females) villagers aged more than 60 years have participated in this study. The villagers were approached and asked about the traditional knowledge on management of paddy straw. The information received from the villagers have been categorized in different sub-headings and reported in this article.

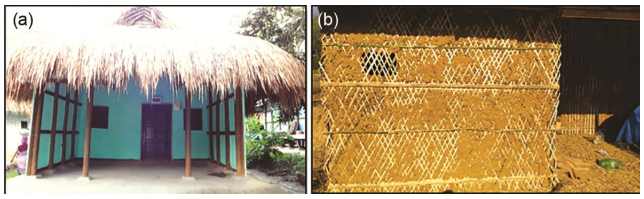

Fig. 2 (a) — Paddy straw as thatching material in traditional house of meitei community (b) Chopped paddy straw mixed with cowdung and mud for wall construction [Photo credit: The pictures were taken from the Andro Village, Imphal East District, Manipur]

Results and Discussion

The application of paddy straw for various purposes are well known to the regions of NE India. It is used as construction materials, animal rearing, fuel, mulching, handicrafts, mushroom cultivation etc. Traditionally, rice straw is also being used in preparation of alcoholic beverage drink made from rice by the local people of NE India. These local beverages has social, cultural and religious importance to the local people[10]. Straw ash was also used as a cleaning ingredient for utensils and preparation of washing material for hair and clothes. Further, it is used for various agricultural unit operations like land preparation, cultivation, plant protection, storage, animal rearing. Besides, traditionally, it is also used for various household purposes which includes thatching, wall construction, fuel for cooking and as raw material for making handicraft products. Data collection were focused on the traditional knowledge of paddy straw management so that researchers can find the scientific exploration for further application in various field.

The information collected from villagers as well as from review of literature on indigenous technical knowledge (ITKs) for the management of paddy straw in NE India are reported in different headings.

Construction materials

Thatching material

Paddy straw is used as thatching material for house as well as an animal shelter. It is still being practiced in rural areas (Fig. 2a). It is believed that this kind of roofing provides a warm effect in the winter season and cooling effect in the hot summer season due to the low thermal conductivity of the roofing materials (weather proofing)[11]. Paddy straw with a thickness of approx. 2-5 cm is fastened using cane/ bamboo strips over split bamboo which is then fixed on the bamboo truss. The thatched roof is replaced once in eight to ten years depending on the thickness and nature of the thatch. It acts as an

excellent sound-absorbing and insulating material[11,12]. Paddy straw thatched roofs provide low cost structure, however, it can also be easily infested by the rodents for its inhabitation.

Wall construction

Two types of wall construction are made using paddy straw, mud, cow dung, and water. In the first one, the entire wall in *Meitei yumjao,* a traditional house of the *Meitei* community of Manipur, is made of chopped paddy straw, mud, cow dung, and water without any reinforcement. The upper layering is done after the lower layer is dried naturally. Another type of wall construction is done using chopped paddy straw, mud, cow dung, and water with reinforcement (Fig. 2b). The mud-straw-cow dung mixture is applied on the reinforcement provided with the woven split-bamboo net in lattice design that formed the skeleton. Later, the structure is then plastered with sand, mud, and cow dung[11-13].

Animal rearing

As feed

Paddy straw is well known to the farmers for its use as cattle feed. However, due to high silica content, its use as animal feed is restricted. High silica content makes the fodder indigestible and unpalatable[4,14]. It is considered a poor quality feed in terms of protein and mineral content[8]. Hence, chopped straws are fed by mixing with green grass, rice bran from rice mills, and oil cakes. Use of paddy straw as feed provides an alternate way of utilizing the agro-based residue.

Paddy straw bedding

Paddy straw bedding is still in use by under privileged and economically backward people in rural areas. Paddy straw bedding is also provided for livestock such as pigs and cattle to protect them from the chill winter. Backyard poultry is very common in rural communities and serves as a means of additional income for farmers especially farm women of NE India. Paddy straw is used as bedding for poultry (ducks and hens) to keep them dry and clean and also for laying and nesting eggs[15]. It is also reported that the use of paddy straw as bedding material especially during winter helps in improving the quality and quantity of milk as it contributed to animals' comfort, udder, and leg health and hygiene[9].

As fuel

Paddy straw has been using as a source of fuel since ancient days. It is also used as fuel in rural areas for heating water especially during the winter season. Fuel cakes are also prepared using chopped straw that is mixed with cow dung, charcoal pieces, husk, sawdust, etc., and make different shapes, dried and stored for future use. Sometimes the chopped paddy straw mixed with cow dung is layered around the dry bamboo stick or twigs to be used as firewood. This fuel is used for cooking in rural areas in *chulla* or opens fire hearth till today. Researchers have also reported the use of paddy straw as fuel in different form[4,5]. Sometimes, paddy straw is also directly used as fuel in rural areas. This not only requires full time engagement during cooking but also create health hazard due to smoke produce.

Mulching

Mulching of soil using paddy straw is being practiced till today since ancient times. Mulching is done to retain the soil moisture and to prevent the seeds from picking by birds. This is mainly practiced in the broadcasting method of seed sowing such as coriander seeds, mustard seeds, etc. (Fig. 3). It is also used as a mulch to protect vegetables from cold winter frost. The straw residue is incorporated in the field itself and thus used to increase the nutrient value or fertility of the soil. Straw is less expensive, readily available, and decomposable, and thus easily affordable to the farmers for use in mulching.

Researchers have also gained knowledge from the traditional methods and started using the paddy straw for mulching purposes scientifically. It has been reported that mulching improves the germination percentage of rapeseed by retaining soil moisture and also increases the residue retention (mineralisable

Fig. 3 — Straw mulching in the broadcasting method of coriander seed sowing. [Photo credit: The pictures was taken from the Khurkhul Village, Imphal West District, Manipur]

Carbon and Nitrogen) in the soil compared to situations where the residue is repeatedly burnt[5].

The straw mulching of crops has been useful in both irrigated and rain-fed environments[14]. Mulching recorded significantly higher lentil seed yield than residue removal[6].

Mushroom cultivation

Cultivation of paddy straw mushrooms is widely practiced nowadays. However, collection of wildly grown paddy straw mushrooms known as *charuyen (Volvariella esculenta*) that are considered a delicacy by the locals of meitei community has been practiced by elders[16]. The season of collection of this mushroom is April to July, during rainy seasons. This particular mushroom is let to grow on its own in the rain-wetted paddy straw heaps kept near the barn. However, this type of mushroom has been consumed since the olden days before the scientific cultivation practices were adopted. Straw is the main substrate for the growth of this particular mushroom. This mushroom is sold in the local market in small quantities by the villagers.

With the scientific intervention, nowadays, the production of mushrooms is being done on a large scale using paddy straw as substrate[4]. The use of paddy straw in the cultivation of milky mushrooms is also reported by other studies[17].

Practicing cultivating paddy straw mushroom not only helps in providing nutritional security to the farmers but also helps in the doubling the farmer's income[14].

Handicrafts

***Doll* (*Laidhi /Laidhibi*)**

The traditional dolls of Manipur are known as '*Laidhi/ Laidhibi*'. The torso and arm of the doll are prepared from the paddy straw (Fig. 4a). The dolls are dressed up in traditional attire of the regions such as *Khamba-Thoibi*, *potloi- Ras-Lila,* etc. (Fig. 4b). These dolls do not only have local importance for ritual purposes but also have demand in the country as well as abroad. The doll itself depicts the culture of the region and kids are very fond of them. Selling and buying these dolls is common during the festivals like *Janmashtami* and *Rathyatra*. Many self-help groups have started producing these dolls to meet the market demand[18,19].

Bags/ Mat/ Pot stand/ Rope

NE India is famous for its handicraft products. Straws are used as raw material for making different handicraft items/ products such as mats/bags. Straws are also made into rope by twisting and making a round shape pot holder, locally known as *Phei* in Manipur for keeping round bottom containers and also hot pots in the kitchen and other general purposes (Fig. 5).

Paddy straw ash

Use for washing utensils

Paddy straw ash left after burning the straw for heating or cooking was used for scrubbing/ washing utensils. All types of ashes are used for washing. However, paddy straw ash is considered as good quality. This may be due to its alkaline nature that can cleanse the oil contents. Brass and aluminium utensils scrubbed with paddy straw ash give a different sheen unlike the chemical detergents, which were favoured in the olden days.

***Liquid filtrate* (*Ooti*)**

The liquid filtrate called *ooti* made from paddy straw ash is known for being used as shampoo, detergents, soaps, and cooking soda used in some culinary preparations in olden days in the NE region especially in Manipur[20]. Paddy straws are burnt to

Fig. 4 — (a) Torso of *Laidhi* made of straw (b) Traditional doll (*Laidhi*) of Manipur. [Photo credit: The pictures was taken from Pheijaleitong, Thongju Part-II, Imphal East District, Manipur]

Fig. 5 — (a) *Phei* made of paddy straw (b) *Phei* used as pot stand. [Photo credit: The pictures were taken from the Andro Village, Imphal East District, Manipur]

collect the ash from which the filtrate is prepared. The ash is wetted with potable water in a small bamboo basket (meruk) layered with cloth or husk for filtration. The filtration is done continuously until a pure brown coloured filtrate is achieved without any solid particles. The filtrate is also used for washing clothes. It is also used in the preparation of special cuisines of Manipur also known as *Ooti.* Nowadays, *ooti* used in the preparation of *Ooti curry* is replaced by sodium bicarbonate. The liquid filtrate thus prepared can also be condensed and processed into soild cake know as Khari and stored for later use. The Khari is usually sold along with Meitei thum (salt cake in Manipur market. Figure 6 shows the process of preparation of *Oati* from paddy straw ash.

Baking of pots

Baking of pots is a general practice among the potters of Manipur to impart hardness, strength and to increase the density of pots. At first, a bed of straw or dry leaves along with cow dung cake is laid on the ground to form a thick bed. The dry pots are then kept gently on the bed and covered with a thick layer of straw and cow dung cake to form a bed for the next layer of pots. Likewise, three or four layers of pots are sandwiched alternatively with the layers of straw and cow dung cake (Fig. 7). Then, the straw is burnt to ash to bake the pots[21].

Fig. 6 — (a) Filling of rice husk for filtration (b) filling of straw ash (c) pouring water to get the filtrate (d) collection of filtrate by natural process. [Photo credit: The pictures was taken from the Khurkhul Village, Imphal West District, Manipur]

Preparation of *Apong*/ local *Yu*

Sekmai, Andro, and Phayeng village of Manipur are also known for their traditionally produced fermented beverages made from rice (*Yu*). Paddy straw is one of the main items used in the different production steps. It is used to layer the bamboo tray (*yangkok*) and basket (*sangbai*) while making a starter (*hamei*). They are sundried for 4 - 5 days depending on the weather conditions, spread without overlapping over the flat and broad baskets with straw/paddy husks lining and covered by cloth[22]. The *hamei* thus prepared from rice powder mixed with the solution of the filtrate dried bark of *Yanglee* (*Albizia myriophylla*) is used as a starter culture for the making of local beer (*Yu*)[23]. Cooked rice properly mixed with powdered *hamei* is put in a basket layered with paddy straw to provide warmth for better fermentation in one step of alcohol production.

Similarly, *Apong*, an alcoholic beverage that has cultural significance, is prepared by the Mising community of Assam and Arunachal Pradesh. *Po:ro Apong* is produced by fermenting a mixture of cooked rice, ash of partially burned paddy husk, and straw with locally prepared E'pob (Starter cake). First of all, a black mass is formed by mixing cooked rice with the ash of paddy husk and straw. E'pob (starter cakes) are pounded into a fine powder and added to the rice-ash mixture (Fig. 8a).

Po:ro Apong is traditionally extracted in a cone-shaped bamboo basket called *Tasuk*. At the base of the *Tasuk*, a pack of *Amrong* (paddy straw) is kept which serves as a sieve while banana leaves covered the sidewalls[10] (Fig. 8b).

Fig. 7 —Baking of earthen pots by the potters [Photo credit: The pictures were taken from the Andro Village, Imphal East District, Manipur]

Fig. 8 — (a) Preparation of starter cake (b) Filtration of *Apong* using straw as base material, Adapted from Pegu *et al*., 2013

Other applications

Making of rope

Rice straw is fibrous and has good strength to be coiled together to make ropes. Farmers prepared rope by twining the straw for general applications which is very common among them. Some farmers used straw ropes to pack the temporary grain storage structures made out of bamboo for sealing[14]. However, the paddy storage structures are made similar to the construction of house walls by mixing chopped straw, mud, cow dung, and water. Paddy straw rope is also used to tied fodder plants and fuel woods[20].

Cushioning materials

Straw is also used as cushioning materials in making mattresses and sofa. Paddy straw is also known for use in bulk packaging of fruits during transportation.

Material for ethnic food preparation

Rice straw is used as a material during the preparation of some ethnic food of NE India. Fermented soybean is prepared and consumed by the people of NE India. In the process of preparation of *trungrymbai*, the local name of fermented soybean of Meghalaya, the beans are soaked, boiled, and fermented. Boiled beans are wrapped with banana leaves and kept in a container (bamboo basket/ aluminum box/steel) and covered with straw, clothes, or gunny bags for incubation of 4-5 days[24]. The method of preparation of fermented soybean is almost the same for all the NE states such as Hawaijar in Manipur, Bekang in Mizoram, Kinema in Sikkim etc.

Yaoshang / Holi festival

Manipur in the NE part of the country celebrates *Holi* festival in a unique form known as *Yaoshang*. The five-day-long celebrations begin with the burning of *Yaoshang* (a small hut) made of paddy straw on the first day. Making of a straw hut and burning it on the starting day of *Yaoshang* is another ritual that is performed during this festival. The straw hut is built using straw and bamboo. Thus straw has also played a very significant role socially[25].

***Farm shed* (*Lou-shang*)**

Small farm sheds or huts are prepared in the field for rest during extreme heat and rain while working in the field. Sometimes farmers stay in this hut overnight to keep an eye on animals from destroying the field. The construction materials are usually bamboo and straw. These are prepared to take rest or to have food after working for several hours in the field.

Making of hardboard

Making of hardboard using paddy straw has been a story for a village named “Irong Chesaba” of Manipur. The village name was derived from the geographical features and the profession of the people living there. “Irong” means the meeting points of two rivers and “Chesaba” means paper making in Manipuri. It is believed that during King Khagemba Maharaj of Manipur, the profession of the people of this village was cultivation and paper making from straw and bamboo. The process of making hardboard involved cutting straw, soaking it in water for 2-3 days, crushing and mixing with gum-like material, and finally sun-drying. However, this practice was not continued as it has been replaced by the advanced technology of paper/hardboard making that made the manual production unprofitable.

The ITKs on paddy straw management in different states of NE India are listed in Table 1.

Traditional method of application of paddy straw for various purposes has certain pros and cons. Researchers have reported the advantages and disadvantages for using paddy straw as listed in Table 2.

Table 1 — Traditional method of paddy straw management in different states of North-East India.

Sl. no	States	Major applications of paddy straw	Reference
1.	Manipur	Thatches of animal shed, bedding for animals, soil composting, cattle feed, mushroom cultivation, mulching, Rope making and packaging material, making of scarecrow	9,14,26
2.	Assam	Preparation of Apong; Tom (Straw bin for storage of rice seed); controlling clay turbidity, controlling insects/pest of coconut; Topa (structure for storing of potato tubers)	10,27–30
3.	Tripura	Piggery shed; mulching; thatching for rural huts, bedding materials for livestock, fodder for cattle, fuel for cooking and binding materials for mud plastering of houses.	31–33
4.	Mizoram	Mulching; bamboo treatment for construction of traditional bamboo houses; animal shed	34,35
5.	Arunachal Pradesh	Preparation of Apong, decomposting (Apatani tribe); To curtail soil erosion/losses of organic matter and fish from canal (Apatani Tribe); mushroom cultivation	10,36–38
6.	Nagaland	Cultivation of rhizominous crops; composting, incorporated into the bunds to clear ways for fish, mushroom cultivation, animal bedding;	39–41
7.	Meghalaya	Construction of Thiar (storage structure of Khasi tribe); mulching, decomposting, bedding for animals, fodder, mushroom cultivation	42,43
8.	Sikkim	Mushroom cultivation; mulching for cardamom cultivation; mulching and storage of ginger	44–46

Table 2 — Advantages and Disadvantages of using paddy straw by traditional method.

Sl. No	Applications	Advantages	Disadvantages	References
1.	Straw burning	Easy in farm operation; Prevention from aphid infestation	Land degradation, Environmental pollution	9
2.	Thatching of rural huts	Thermal insulation; temperature stability	Need to change in a year or two	4
3.	Animal feed	Feed availability is maintained during the dry season	High silica content in rice straw decreases the digestibility of rice straw when used as fodder	47
4.	Bedding materials for livestock and poultry	Low cost, provide cushioning	Require to change frequently	-
5.	Straw as fuel	Alternate source of fuel in rural areas	Environmental pollution, health hazard, full-time engagement during cooking	-
6.	Binding materials for mud plastering of houses	Low cost, low bulk density, low heating value, high ash content,	hygroscopic nature, low energy density, and poor grindability	48
7.	Wall construction	Low cost, easy to construct by local artisian, temperature stability	Can be easily affected by rain due to high water absorptivity	-
8.	Mulching	• Protect young plants from harsh heat and cold • Reduced weeds and aphid infestation • Soil and water conservation	Labour intensive	49–51
9.	Lining/cushioning materials for the transportation of fruits (e.g., watermelon)	Provides cushioning, low cost	Labour intensive	47

Conclusion

NE India is a rich source of traditional knowledge in the management of paddy straw. Proper management of rice straw becomes the need of the hour to solve the existing problem of paddy straw burning and utilizing it in various ways as it has been doing since ancient days. Management of the paddy straw starts just after harvesting. Collection, densification, storage, supply, and process for various applications are the main steps for proper management.

Some of the ITKs of paddy straw management are well known such as used as construction material, mushroom cultivation, animal bedding, handicraft products etc. and it is still prevailing till today. The scientific explanation behind its application is yet to be explored. Therefore, there is a need to provide awareness to the farmers, entrepreneurs, industries, and other stakeholders for the management of paddy straw through its various application and ITKs.

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Conflict of Interest

The authors have no conflict of interest to disclose.

Authors' Contributions

The authors have contributed equally in collecting information and preparing the manuscript.

References

1 Anonymous, State/Season-wise Area, Production and Productivity of Rice in India 2018-19, *Indiastat focused on facts*, (*https://www.indiastat.com/table/template/agriculture/state-season-wise-area-production-productivity-ric/1208730*), 2022.

2 Anonymous, Rice Straw Management, *International Rice Research Institute*, (*https://www.irri.org/rice-straw-management*), 2018.

3 Nath H, Das S & Das J, A study on the potential biomass available in Northeast India for its applicability in certain clean energy generation purposes, *J Inst Eng India Ser E*, 101 (2) (2020) 133–140, DOI: 10.1007/s40034-020-00166-1.

4 Roy P & Kaur M, Status and problems of paddy straw management in West Bengal, *Int J Adv in Agric Envir Engg* (*IJAAEE*), 2 (1) (2015) 44-48, DOI: 10.15242/IJAAEE.ER1015204.

5 Singh L N & Irungbam P, Practices of burning rice stubble in zero tillage rabi crops – Merits & demerits, In: *Brainstorming Workshop on Rice Residue Burning in Manipur – Issues and Strategies for Sustainable Management*, Volume 1, (Indian Association of Hill Farming, Imphal, Manipur), (2018) p. 14-19.

6 Devi M T, Layek J, Kumar B, R K, Babu S, *et al*., Management of rice residue for sustaining soil health in conservation agriculture, In: *Brainstorming Workshop on Rice Residue Burning in Manipur – Issues and Strategies for Sustainable Management*, Volume 1, (Indian Association of Hill Farming, Imphal, Manipur), (2018) p. 20-29.

7 Anonymous, Threshing, *IRRI Rice Knowledge Bank*, (*http://www.knowledgebank.irri.org/step-by-step-production/postharvest/harvesting/harvesting-operations/threshing*), 2022.

8 Singh R B, Sana R C, Singh M, Chandra D, Shukla S G, *et al*., Rice straw – its production and utilization in India, In: *Handbook for Straw Feeding Systems*, (Kiran Singh and J.B. Schiere, ICAR, New Delhi, India), (1995) 325-337.

9 Devi M L, Devarani L, Singh R & Hemochandra L, Rice straw management in Manipur: Challenges and finding a way forward, *Indian J Hill Farming*, (Special Issue 2020) (2020) 44-49.

10 Pegu R, Gogoi J, Tamuli A, Teron R & Anglong K, Apong, an alcoholic beverage of cultural significance of the Mising community of Northeast India, *Glob J Interdisc Soc Sci*, 2 (6) (2013) 12-17.

11 Sapha Y & Apanthoi M W, The Meetei Yumjao: A cultural symbol, *J Emerg Technol Innov Res*, 5 (12) (2018) 514-523.

12 Nganthoi S & Tondonsana Singh N, Seismic resistant bamboo house in Manipur, *J Xi'an Univ Archit Technol*, 12 (11) (2020) 96-109.

13 Devi T K & Elizabeth S, Seismic protection of non-engineered building in North East India, *Int J Eng Adv Technol*, 5 (2) (2015) 125-129.

14 Shashidhar K S, Bhuvaneswari S, Premaradhya N, Kumar S & Jeberson S, Sustainable options for rice residue management in Manipur, *CAU Farm Magazine*, 8 (4) (2018) 2-6.

15 Kadirvel G, Agri - Kaleidoscope - Animal genetic resources of North Eastern hill region of India, *KIRAN Empowering Agric Know Inno in North East*, (*http://www.kiran.nic.in/genetic_animal.html*), 2021.

16 Anonymous, Edible mushroom of Manipur, (*https://nlc.manipurforest.gov.in/wp-content/uploads/2020/01/mushroom....-NATURE.pdf*), 2020.

17 Vijaykumar G, John P & Ganesh K, Selection of different substrates for the cultivation of milky mushroom (*Calocybe indica* P & C), *Indian J Tradit Know*, 13 (2014) 434-436.

18 Sunita A, Laiphadibi: The Cloth dolls that guard and guide manipuri people, *Sahapedia*, (*https://www.sahapedia.org/laiphadibi-cloth-dolls-guard-and-guide-manipuri-people*), 2019.

19 Thokchom K, Laidhi steps into Barbie shoes - Cloth-and-straw doll gets a makeover, (*https://www.telegraphindia.com/india/laidhi-steps-into-barbie-shoes-cloth-and-straw-doll-gets-a-makeover/cid/801404*), 2006.

20 Salam S, Ethnobotanical study of the Tangkhul naga tribe in Ukhrul district, Manipur state, Doctor of Philosophy in Botany, (Nagaland University, Lumami), 2013.

21 Anonymous, Miscellaneous Arts and Crafts in Manipur | IGNCA, *Indira Gandhi National Centre for the Arts*, (*http://ignca.gov.in/divisionss/janapada-sampada/northeastern-regional-centre/miscellaneous-arts-and-crafts-in-manipur/*), 2021.

22 Soibam H & Ayam V S, The traditional fermented foods of Meiteis of Manipur, India: A case study, *J Pharmacogn Phytoch*, 7 (8) (2018) 535-539.

23 Nath N, Ghosh S, Rahaman L, Lalbhovika D & Sharma B, An overview of traditional rice beer of North-east India: ethnic preparation, challenges and prospects, *Indian J Tradit Know*, 18 (4) (2019) 744-757.

24 Das P, Das S K, Arya H P S & Reddy G S, Inventory of indigenous technical knowledge in Agriculture, 2002.

25 Singh S A, Holi 2021: A virtual tour of Holi hotspots, *Free Press Journal*, (*https://www.freepressjournal.in/weekend/holi-2021-a-virtual-tour-of-holi-hotspots*), 2021.

26 Akoijam A S & Mahongnao M, The challenges of adopting innovative agricultural practices under shifting cultivation in Northeast, *NEHU J*, 16 (1) (2018) 31-52.

27 Deka S, Nath R K, Sehgal M, Ahuja D B, Kakoti R K, *et al*., Indigenous technological knowledge (ITK) and practices in pest management of Assam, *Ann Plant Prot Sci*, 25 (1) (2017) 119-125.

28 Devi R, Saha B, Pandit A & Kashyap D, Assessment of applicability of Indigenous Technical Knowledge (ITK) in aquaculture as perceived by fish farmers in Assam, *Indian J Fish*, 61 (3) (2014) 104-110.

29 Ngachan S V, Mohanty A K & Pattanayak A, Status paper onrice in North East India, 2011.

30 Upamanya G K, Sarma H, Sarma R & Helim R, Topa: A unique storage structure for managing potato tuber moth, *Asian Agri-History*, 18 (2) (2014) 191-194.

31 Ahmed N, Doley S, Ahmed K & Das B, Socio-economic status of small scale pig farmers in rural communities of Tripura, *Int J Chem Stud*, 5 (3) (2017) 102-104.

32 Das A, Ramkrushna G, Yadav G S, Layek J, Debnath C, *et al.*, Capturing traditional practices of rice based farming systems and identifying interventions for resource conservation and food security in Tripura, India, *Appl Ecol Environ Sci*, 3 (4) (2015) 100-107.

33 Patel LC, Nath D, Islam N, Biswas S, Shil S, *et al*., Dissemination of outcome of climate resilient agricultural technologies in a tribal village of Tripura, *Intl J Farm Sci*, 4 (4) (2015) 272-278.

34 Das P, Korde C, Sudhakar P & Satya S, Traditional bamboo houses of north-eastern region: A field study of Assam & Mizoram, *Key engineering materials*, 517 (1) (2012) 197-202, DOI: 10.4028/www.scientific.net/KEM.517.197.

35 Singh B K, Pathak K A, Boopathi T, Ramakrishna Y, Verma V K, *et al*., Horticulture based farming system in Mizoram: An Alternative to Jhum Cultivation, 2013.

36 Kala C P, Dollo M, Farooquee N & Choudhury D, Land-use management and wet-rice cultivation (Jebi Aji) by the Apatani people in Arunachal Pradesh, India traditional knowledge and practices, *Outlook Agric*, 37 (2) (2008) 125-129, DOI: 10.5367/000000008784648906.

37 Singh R D & Munda G C, Status of natural resources and suitable crops & cropping systems for North Eastern region, *Agric Sit India*, 1 (1) (2008) 3-9.

38 Singh S P, Bhagawati R & Chandra A, Economics of substrates in cultivation of Oyster Mushroom *(Pleurotus djmore* and *P. Sajor-caju*) in Arunachal Pradesh, *Ann Pl Protec Sci*, 20 (2) (2012) 403-406.

39 Amenla I & Shuya K, Zabo (Zabü) farming of kikruma village, Nagaland, India, In: *Innovations in agricultural extension*, (Michigan State University), (2021) p. 1-11.

40 Anonymous, Agriculture Contingency Plan for District: MON, *(http://agricoop.gov.in/sites/default/files/NL4-Mon-20.11.2014_0.pdf*), 1-27.

41 Anonymous, Agri - Kaleidoscope - Practices unique to Nagaland, *KIRAN Empowering Agric Know Inno North East*, (*http://www.kiran.nic.in/nagaland.html*).

42 Borah S, Mahanta J, Singh NAK, Sangma A N, Marak T R, *et al*., Potential uses of paddy straw (Alternatives to Burning practices of paddy straw), 2017.

43 Jeeva SRDN, Laloo R C & Mishra B P, Traditional agricultural practices in Meghalaya, North East India, *Indian J Tradit Know*, 5 (1) (2006) 7-18.

44 Singh S, Avasthe R, Raj C, Kapoor C & Lepcha S C, Spent mushroom substrate - A multifaceted utility for organic Agriculture, *CAU Farm Magazine*, 10 (1) (2020) 2-6.

45 Vijayan A K, Gudade B A, Gautam A, Deka T N, Bora S S, *et al*., Cultivation of ginger in Sikkim under an organic system, In: *Ginger Cultivation and Its Antimicrobial and Pharmacological Potentials*, (IntechOpen), (2020) 1-12. ISBN: 978-1-83880-030-7.

46 Viji, Cultivation of large cardamom in Sikkim, *Vikaspedia*, (*https://vikaspedia.in/agriculture/crop-production/technologies-for-ne-india/spicrd/cultivation-of-large-cardamon-in-sikkim*), 2016.

47 Van Hung N, Maguyon-Detras MC, Migo MV, Quilloy R, Balingbing C, *et al*., Rice straw overview: Availability, properties and management practices, In: *Sustainable Rice Straw Management*, edited by Gummert M, Hung NV, Chivenge P, Douthwaite B, (Springer International Publishing, Cham), (2020) 1–13, ISBN: 978-3-030-32373-8.

48 Werther J, Saenger M, Hartge E U, Ogada T & Siagi Z, Combustion of agricultural residues, *Prog Energy Combust Sci*, 26 (1) (2000) 1-27, DOI: 10.1016/S0360-1285(99)00005-2.

49 Ahmad F, Sustainable agriculture system in Malaysia, In: (United Nations Conference Complex, Bangkok, Thailand), 2001, 1-10.

50 Kanokkanjana K & Garivait S, Alternative rice straw management practices to reduce field open burning in Thailand, *Int J Environ Sci Dev*, 4 (2) (2013) 119-123, DOI: 10.7763/IJESD.2013.V4.318.

51 Saucke H & Döring T F, Potato virus Y reduction by straw mulch in organic potatoes, *Ann Appl Biol*, 144 (3) (2004) 347-355. DOI: 10.1111/j.1744-7348.2004.tb00350.x.