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CROP WASTE TO FOOD PLATE

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Foreword

Agricultural production systems in India suffice the requirement of food for a vast population and generate plenty of bi-products and wastes which need to be managed properly. In certain cases these wastes and bi-products are a cause of concern from environmental points of view. But meticulous utilization of these wastes and bi-products could not only be helpful in diversification of agriculture but also in generation of employment and additional income. Besides, it is helpful in supporting cottage industries in rural areas. Scientific utilization of agricultural waste and bi-products for mushroom culture could be an ideal option for enhanced income of famers and augmenting nutritional security of a large population in far flung regions of the country.

I am happy to note that concerted efforts of scientists at the ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru has resulted in standardization of several technologies useful for culture and processing of mushrooms for production of value added preparations. It is high time that these high impact technologies are demonstrated to stakeholders and commercialized for wider adoption. It is in this context that the Technical Bulletin "*CROP WASTE TO FOOD PLATE*" has been published by the ICAR-IIHR, Bengaluru. It focuses on eco-friendly solution to the problems associated with management of crop residues by utilizing these bi-products and crop wastes for culture of mushroom which can spin off many other important socio-economic and environmental benefits. I hope that the scientific information provided in this publication will be helpful in translating the research results into their practical application in the field for meaningful purposes.

I congratulate the team of scientists for their efforts in compiling this useful literature and wish them all the best in their future scientific pursuits.

(Anand Kumar Singh)

Crop residue waste scenario in India

India being an agrarian country, produces more than 500 million tons (Mt) of crop residues annually (MNRE 2009). It is generally estimated that every 1kg of any cereal grain production leads to 1.1-1.5kg of waste production (Combustion Gasification & Propulsion Laboratory (CGPL), IISc, Bangalore, India, http://cgpl.iisc.ernet.in). These residues are variously used as animal feed, thatching of homes, source of domestic and industrial fuel etc. However, despite its various usages, a very high proportion of unused crop residues are burnt in the fields. Non-availability of labour, high cost of residue removal from the field and increasing use of combines in harvesting the crops are main reasons behind burning of crop residues in the fields. Burning of crop residues causes environmental pollution, is hazardous to human health, produces greenhouse gases causing global warming and results in loss of plant nutrients like N, P, K and S. Therefore efficient, productive, profitable and eco-friendly management of crop residues assumes a great significance. Numerous competing uses of crop residues like Livestock feed, compost making, energy resource, biofuel & bio oil production, gasification, biochar production have been promoted. One of the most efficient use of crop residue can be Mushroom cultivation which will not only utilize the waste in a greener way but will result in the production of highly nutritious and medicinal vegetable (mushroom) which can play a pivotal role in malnutrition mitigation as well. The major crop residues are produced by cereal crops followed by fibre, oilseeds and other crops (Fig. 1)

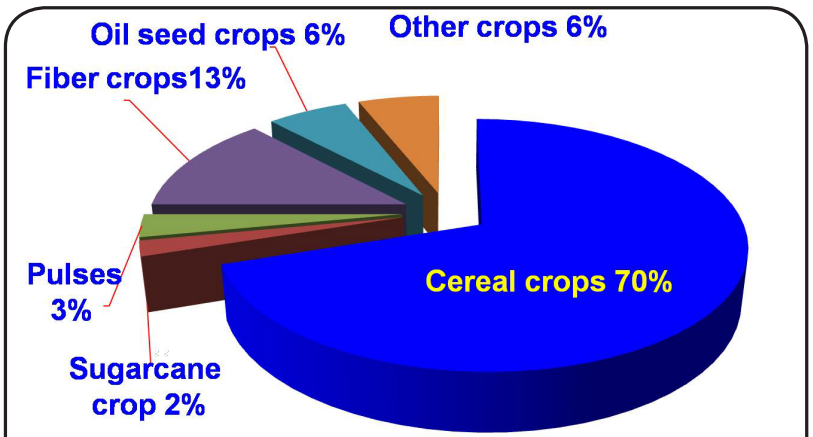


Fig.1. Crop residue generation in India (MNRE 2009)

A report on crop residue management with conservation agriculture (2012) estimated that about 91-141Mt of different crop residues are surplus and not used at all. These surplus crop residues are either burnt or ploughed back in the field.

Cereal crop accounts for 58% of the unused surplus residues followed by fibre crops (23%) in addition to 2% from sugarcane, 3% from pulses, 6% from oilseed crops and 6% from other crops (Fig.2.)

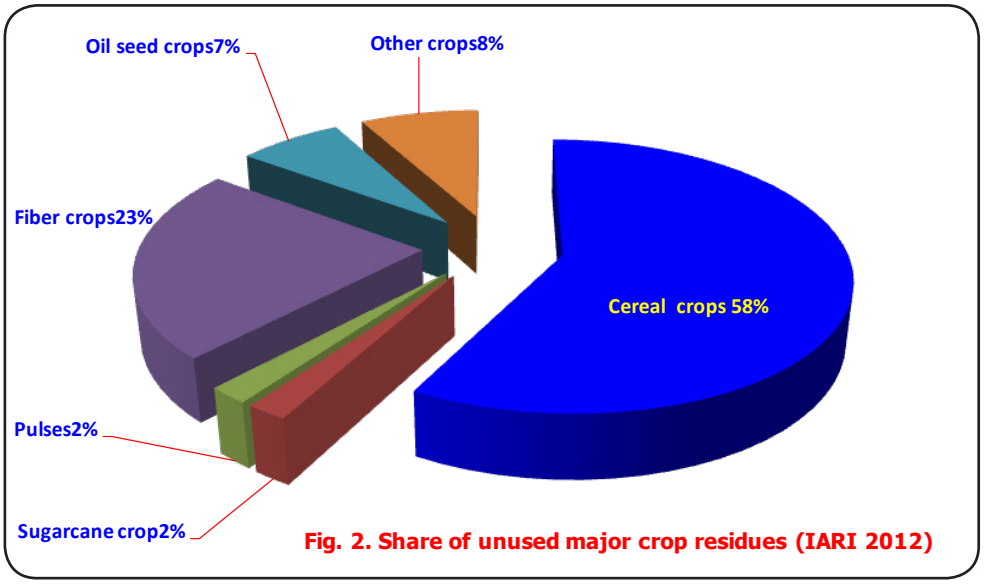


Fig. 2. Share of unused major crop residues (IARI 2012)

Potential of utilizing crop residues for mushroom cultivation

Major crop residues which are burnt on farm comprise of rice(44 Mt), wheat (24.5 Mt) and fibre crops (33Mt), cotton stalks (11.8Mt), pigeon pea stalks (9.0 Mt), jute and Mesta (1.8 Mt), groundnut shell (5.0Mt), rape seed& mustard (4.5Mt) and sunflower (1.0Mt). All these crop residues are excellent substrates for mushroom cultivation. Jain et al (2014) estimated that 98.4Mt of crop residues are burnt annually in India. The estimated potential of mushroom production and other related benefits of using even 10% of the surplus crop residues is shown in Table1& 2.

Table 1. Estimated mushroom production by using 10% of surplus crop residues burnt annually in India

Surplus crop residues burnt in the country per annum	98.4 million tons (Mt)
10% of this crop residue	9.84 million tons per annum
Fresh oyster mushrooms which can be produced through 9.84 million tons @50 % biological efficiency	4.92 million tons per annum

Advantages of using crop residues for mushroom production

Mushrooms are vegetables that are full of nutrients and therefore can make a very valuable contribution to human nutrition especially in a country like India where the predominantly vegetarian population suffers from acute malnutrition. Edible mushrooms provide high quality protein that can be produced with greater biological efficiency than animal protein. Mushrooms rank very high in vitamin content especially B vitamins as compared to most of the common vegetables eaten in the Indian diet. The riboflavin, thiamin, Vitamin B12, and niacin content of mushrooms is very high. Mushrooms are the only vegetarian source of Vitamin D. Mushrooms is a good source of minerals like potassium, calcium, phosphorus and iron. Being low in carbohydrates, very low in sugars and low calorie food, mushrooms are recommended diet for diabetics. Their very low sodium content makes them ideal food for patients with high blood pressure. Being high in fibre and very low in fats, it is recommended as an ideal food to lose weight. Mushrooms are also regarded heart healthy foods due to their ability to reduce cholesterol and lipids. Many of the edible species have shown remarkable anti-cancerous properties. Mushroom cultivation being highly labour intensive can create employment for rural sector especially for women. Mushroom cultivation can be beautifully integrated in many of the rural upliftment policies of the Government of India. For e.g Mahatma Gandhi Rural Employment Guarantee Scheme (MANREGA), Mid-day meals and Aaganwadi. The unemployed rural youth, landless and women groups can be engaged in a centralized mushroom growing farm at Panchayat levels. Utilization of cereal crop residues for mushroom cultivation will also help in lowering air pollution (Table-2) because burning of cereal crop residues increases air pollution extensively.



Table 2. Estimated Socio-economic & Environmental benefits by using 10% of surplus crop residues for mushroom cultivation

ESTIMATED SOCIO-ECONOMIC & NUTRITIONAL IMPACT ;	
	ESTIMATED IMPACT PER ANNUM
Mushroom produced through utilization of 10% (9.84Mt) crop residues @ 0.5 Kg fresh mushroom per Kg residue	4.92 Million Tons
Employment generated @ 150 mandays/ton fresh oyster mushroom/annum	738 million mandays or 2.02 million people can be employed every year
Protein produced @ 2.5% of fresh weight	123000tons per annum (@60 g per capita consumption per day, 56 lakhs people's protein requirement is met)
Non-cultivable land used for production @ 0.1ha / ton	49200ha
ESTIMATED ENVIRONMENTAL IMPACT	
Paddy/ wheat straw recycled	9.84Mt
Spent mushroom substrate (SMS) produced after crop harvest for organic manure @60% of dry straw used	5.9Mt
***PREVENTION OF AIR POLLUTION**	
Reduction in release of particulate matter @ 3ton/Mt straw	29.5 ton
Reduction in release of carbon monoxide (CO) @ 60 ton/Mt straw	590.4 ton
Reduction in release of Carbon-di-oxide (CO_2) @ 1460 ton/Mt straw	14366.4 ton
Reduction in release of ash @ 199 ton/Mt straw	1958.2 ton
Reduction in release of Sulphur di-oxide (SO_2) @ 2 ton/Mt straw	19.7 ton

***Source : Gupta et. al. (2004)**

Back to Mother earth

Mushroom cultivation process utilizes the wastes generated by other crops and gives in return nutritious vegetable. The substrate or compost that remains after harvesting the mushrooms (spent mushroom substrate, SMS) is further utilized as animal feed or as soil conditioner. Research shows that substrate left after oyster mushroom cultivation can be utilized to produce highly digestible nutritious feed for

cattle and sheep. Spent substrate/ compost can also be added to the fields as manure which can increase organic carbon content of the soil as well. Spent substrate from oyster, Milky and shiitake mushroom farms can be further composted for 3-4 weeks, dried, packed and can be sold as an excellent nursery medium. The straw based spent substrate of oyster mushroom can also be utilized for the multiplication of the biological control agent *Trichoderma* by the farmers in their own fields (Pandey et. al., 2014). This will have a dual impact of adding the bioagent along with organic manure. The mushroom SMS can also be utilized for making fuel briquets, as feed for biogas, as partial de-lignified substrate for ethanol production, for making novel biodegradable packaging boxes etc.

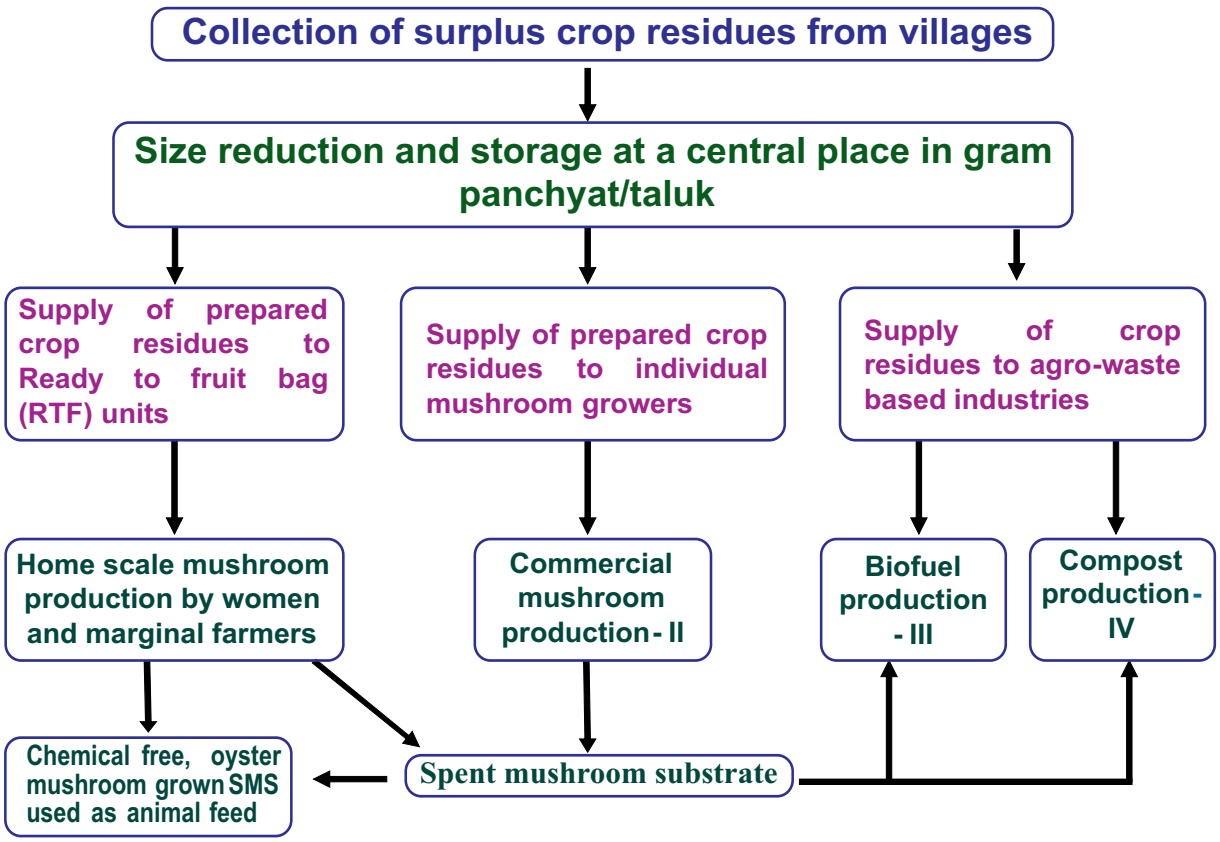
ICAR-IIHR CONCEPTUAL MODEL FOR CREATING WEALTH FROM AGRICULTURAL WASTE

There is a need to create single window availability of agricultural wastes which can be very effective in agricultural waste management of the entire country. This can be taken up as a start-up model or a network model involving all villages. This will facilitate availability of agricultural wastes wherever required instead of being burnt due to non-availability of such facilitation centres. The following is a conceptual model developed by ICAR-IIHR, Bengaluru in this direction. Krishi Vigyan Kendras (KVKs), State agriculture/ horticulture departments and village panchayats can become partners in such network. This can also be partnered with corporate sectors through their corporate social responsibility (CSR) and the agencies or Non-Government organizations (NGOs) working in environment protection.

ICAR-IIHR offers

- Commercial cultivation technology of many culinary medicinal mushrooms
- Entrepreneur training courses both for mushroom cultivation and mushroom spawn production.
- Technical guidance to organizations and individuals to establish mechanized spawn production labs and Ready to fruit (RTF) bag production units.
- Quality spawn of the commercial mushroom species can also be obtained on prior order basis.
- Technology for mushroom fortified value-added products for nutrition enhancement

ICAR-IIHR MODEL FOR SINGLE WINDOW CROP RESIDUE MANAGEMENT



Benefits is through the Above model

I

1. Enhancement of household nutrition
2. Availability of fresh mushrooms for midday meal for village school
3. Supplementary income through sale of fresh or processed mushroom or mushroom products

II

1. Economic activity for self employment and generation of additional employment for marginal, small scale farmers, landless people, women, differentially abled people of the village
2. Enhancement of household nutrition
3. Availability of fresh mushrooms for midday meal for village school
4. Supplementary income through sale of fresh or processed mushroom or mushroom products

III

1. Economic activity
2. Employment generation
3. Betterment of environment through Prevention of pollution

IV

1. Economic activity
2. Employment generation
3. Betterment of soil health
4. Promotion of organic farming

NET OUTCOME OF THE ICAR-IIHR MODEL

1. Efficient collection, storage and availability of crop residue for economic activities like mushroom cultivation, compost preparation, biofuel etc.
2. Employment generation through collection and transportation of the biomass
3. Reduction in air pollution due to burning of such crop residues
4. Villages will become clean (swatch gram)
5. Single window availability of raw materials for biomass-based activities in villages
6. Additional regular income to the farmer through sale of crop residue
7. Creation of rural self-employment through mushroom cultivation and better quality of mid-day meals through incorporation of mushrooms produced in the village itself.
8. Availability of nutritious and healthy food (mushrooms)
9. Central composting yards in villages to make their own compost
10. Surplus unutilized biomass at village/taluk level can be transported to district level warehouses which can be a single window system for agricultural/ industrial enterprises in peri-urban and urban areas

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COMPARATIVE STRATERGIES FOR CROP RESIDUE MANAGEMENT