ROLE OF EXTENSION EDUCATION IN MANAGEMENT OF HORTICULTURAL CROP RESIDUES

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ABSTRACT

Horticulture is an art and science mainly concerned with cultivated plants directly used by people for food, medicine and aesthetic gratification. Its enormous residues/waste are source of important raw materials for other industries/factories after recycling and processing. Utilization of these materials in proper manner prevents the huge loss of untapped biomass and environmental hazards issues. The proper utilization of horticulture residues such as peels (fruits/vegetables), leaves, stems, stalks, inflorescences, flowers, etc. that are unsuitable for consumption or cannot processed or left on the field after harvest, can serve as an important alternative source of plants nutrients (macro and micronutrients), livestock feed, bio-fertilizers, fibres and bioactive compounds etc. Future challenges, expectations, sustainability and feasibility of utilizing these residues are the important key factors for horticulture waste management. Thus, Agricultural extension has become a centre of attention in work out and publicizing knowledge and helping Indian farmers to be a proficient and qualified decision makers in converting horticultural residues into highly commercial outputs for sustainable renewable resource which will be an important source of additional income. This research article will provide a conceptual and theoretical framework for agricultural extension education in management of horticultural crops residues in views of environmental issues, bio-safety and bio-diversity conservation.

Keywords: Horticulture, agricultural extension, residues management, environmental issues, competent decision maker.
INTRODUCTION

Being an agriculturally dominant nation, India has a vast land commercially utilized for cultivating and orcharding diverse horticultural crops in different agro-climatic topography. In India, 90% of the total horticulture production comprises of fruits and vegetables. In global scenario, next to China, India is the leading producer of fruits and vegetables and it is leading producer of banana, mango, papaya, cashew-nuts, areca nut, potato and okra (Anon. 2018). In spite of its leading status in horticulture crops production it is also one of the leading producer of horticulture crop residues/wastes which are produced both on and off-farm (Table 1). Gupta and Joshi (2000) also reported huge production of fruit and vegetables processing waste as illustrated in Table 2. According to the reports of Ajila et al. (2010) some fruits and vegetables produced 25-30% of non-edible products which are considered as wastes/residues. Nanda et al., (2012) reported a total loss of 5.8-18.1% fruits, and 6.9-13.0% vegetables during harvest and post-harvest operations, handling and storage in India. Wadhwa and Bakshi (2013) and other works also reported a huge quantity of waste (1.81 million tonnes) after processing were being generated, packing of the products, distribution and consumption in organized sector from fruit and vegetable processing industry in India (Table 1). Very frequently a huge quantity these crops residues are burned or dumped in rivers and landfills, due to unavailability of labour and high charges of residual removal from the orchards/crop fields. Such uncontrolled disposal of crop residues ultimately resulted in unhygienic polluted environment by releasing huge amount of greenhouse gases and toxic substances in soil which ultimately affect both plant (resulted in loss of key plant nutrients like N, P, K and S) and human health. Alternatives to such disposal methods, proper management of these crop residues by encouraging the farmers through vocational training can reduce the environmental, plants and human related issues. Thus, from the horticultural point of view ‘Waste Management Extension’ plays an integral part of agricultural system which helps farmers to making relevant decisions, rather than intervening or influencing in their decisions in boosting the productivity of farming. It includes or among them, agricultural researchers, some farmer’s organizations, government authorities, non-government organizations (NGOs), most of the training centres for farmer and the media persons. This system accelerates the functioning of research, information publicizing, training and so on. Through the capacity building of extension services, various stakeholders (farmers and extension functionaries) under crop development programmes and field level demonstrations (on crop residues management) can have the knowledge of converting these residues into highly commercial outputs for sustainable renewable resource and providing them additional income.

HORTICULTURAL CROP RESIDUES

Horticultural crop residues are production residues that are produced from the integral part of the commercial horticultural crops production. The production residue is not the end product that the production process produced. Depending on the circumstances, it may or may not be wastes.

1. According to the ‘List of Wastes (England) Regulations 2005’, a crop residues may be called wastes, they will fall under the category of ‘02 01 03’ (plant-tissue waste) or ‘02 03 04’ (materials which are unsuitable for processing or consumption).
E.g. Food (fruit and vegetables) scraps or leftovers from households or restaurants

2. Crop residues which are not wastes are misshapen, bruised and undersized fruit and vegetables graded and sorted out before packing, sale and consumption. All parts of fruit and vegetables (leaves, stem, root etc.) which are not consumed by consumer are also crop residues which are not waste.

MANAGING FRUIT AND VEGETABLE WASTE (Technology needed to be transferred to farmers through extension services)

The horticultural waste from food processing industries are of immensely diverse due to the utilization of numerous vegetables and fruits, the multiplicity of the product and the wide range of processing (William, 2005). According per the reports of Ajila et al. (2010) fruits and vegetables produced 25-30% of non-edible products which are considered as wastes/residues. In present days, 100% utilization of horticultural produces are the requirement and demand of peoples to imply low-waste technology in their agribusiness. As stated earlier proper management of horticulture residues can reduce effectively to environmental issues and also protects the one who is equally responsible. Some important management methods suggested by Hawkins (2013) and IARI (2012) for fruits and vegetables residues are as follows:

1. **Piling up of fruit and vegetables residues on a site for a limited time:** It is a low cost disposal temporary method prior to final disposal or reuse of the plant products. The crops residues are usually transferred via heavy vehicles to the location prepared for holding the residues. The holding area should be bermed at a minimum level to accumulate or hold the rain water and any form of liquids which were formed from the decomposition of the fruit and vegetable residues. Important process includes the crushing of crop residues in the bermed area and allows the liquid formed to be evaporated and left for decomposition. Generally decomposition will start in weeks and the crop liquid extract will gradually evaporate and infiltrate into the ground. It has disadvantages like the production of potential unsightliness and odours to the surroundings.

2. **In-situ disposal of crop residues where it was grown:** From the viewpoint of an agricultural nutrient management and organic building, returning crops residues to the field may be considered as one of the better options. This is cheap way of management methods that allow the disposed residues to decompose in the growing field in which the nutrients can be recycled, thus increasing soil nutrient status and carbon. It has disadvantages like disease transmission from bad crops and residues cannot be disposed when there is crop in the field.

3. **Feeding livestock:** In most part of India, the horticultural crops residues are dispose to feed the animals with some additives as supplements. But to due to the main factor of the crop residue being unpalatable by the animals cannot be replaced as sole ration for the livestock. The crop residues are low in nitrogen, low in density fibrous materials, soluble carbohydrates, vitamins and mineral with varying amounts of lignin can act as physical hurdles and slower the process of microbial breakdown. In order to make the crop residual consumable and more nutritional for feeding to the animals, there is need to processing and enriching it with molasses, urea and supplementing with legume (gram, cowpea, horse gram and sun hemp) straws and green fodders (leguminous/non-leguminous).
4. **Raw unit for compost:** It is cheap disposal methods that can minimize the quantity of crops residues as well as other “waste” materials in a community. Vegetable and fruit wastes can be composted and used to replace a significant part of the mineral nitrogen fertilisation with nitrogen recovery of 6–22 percent. The long-term compost applications improved the nitrogen status of the soil over the years (Tits *et al.*, 2012). The residues should be mixed in proper ratios with other organic materials (animals’ urine and dung) as recommended by composting professionals to produce compost suitable for reincorporation into fields or for selling. Indian Agricultural Research Institute (IARI), New Delhi, has successfully developed a biomass-compost unit for making of good quality compost. This mechanized unit efficiently uses waste biomass and crop residues generated in the IARI farm. The decomposition process, which is hastened by a consortium of microorganisms, takes 75-90 days. Agricultural waste, horticultural waste, animal waste, silkworm litter, plant biomass (leaf litter), weeds, kitchen waste abiding, foul, acidic, spicy and spoilt food, city refuse after removing non-degradable waste material such as glass, plastic, strong rubber and metal can be vermi composed (Kale, 1995).

5. **Source of bio-fuels:** The biological principles involves in this methods is ‘The conversion of lignocellulosic biomass into alcohol.’ The alcohol produce here is ethanol which is of immense importance and blended with gasoline as a fuel extender and octane-enhancing agent or used as a neat fuel in internal combustion engines. The technology of ethanol production from crop residues is, however, evolving in India. There are a few limiting steps in the process of conversion of crop residues into alcohol, which need to be improved. High energy requiring operating conditions, costly hydrolytic cellulase enzyme, and unavailability of natural robust commercial organism to ferment pentose and hexose sugars simultaneously either as single species or in combination of other species are some of the constraints, which require additional research efforts. Lalitha and Sivaraj (2011) reported the production of ethanol from the fruit biomass peel residue in Tamil Nadu.

6. **Source of raw materials for other industry:** Many crop residues are the important raw materials resource of for other industry. By-products of banana have been used for wrappings foods, clothes and have been used in many ceremomial occasions and the usage expands through cultural diversification (Kennedy 2009). Studies on the cellulosic fibres from other agricultural wastes such as from the oil palm industries indicated the great potential of these by-products to become a commercial raw material in making highly demanded products such as paper and fiber composites (Bakar *et al.*, 2007; Wan Rosli *et al.*, 2007). The citrus industry produced large amounts of byproducts. Oils obtained from skin have been used for different applications. Studies of the application of lemon extract on dairy products have also been performed (Conte *et al.*, 2007).

7. **In bio-methanation:** This process utilizes the crop residues in a way of non-destructive to extract high quality fuel gas and produce manure to be recycled in soil. Horticulture residues incorporation with the biomass such as rice straw can be converted into biogas, a mixture of carbon dioxide and methane, which can be used as fuel. About 30 percent of the total production of Chinese cabbage is discarded as waste. According to Liu *et al.*, (2009) mesophilic fermentation condition was more suitable compared
with thermophilic condition for biogas production from cabbage leaves. Gunaseelan (2004) obtained a methane yield of 309 and 291 mL/g volatile solids (VS) from cabbage leaves and stems respectively. The process also yields good quality spent slurry, which can be used as manure. This technology has been successfully demonstrated by various organizations such as IARI and PAU, Ludhiana.

8. **Food banks**: The good fruits and vegetables resulting from the sorting which is usually regarded as a residue commercially are the main component of these methods. Giving these residues to a food bank is the act of the ‘Good Samaritan Law’ and will also help the organising company. Since most of the fruit and vegetables are perishable in nature, so immediate utilization is required for which the farmer must always get in touch with the local food bank personals. This method is usually seen in the developed countries and recently many states of India are adopting this method.

9. **Natural source of food additives and dietary nutrients**: A substantial part of the waste produced during the handling and processing of horticulture crops especially fruits and vegetables still comprises important quantity of the original plant materials (Peels, seeds, leaves, stems, barks, and roots). High-value natural compounds can be found in most of these fruit and vegetable residues, many of them having health-promoting characteristics (Table 3). Many research reported the used of these residues in nutritional food products such as used of carrot pomace in bread (Osawa et al., 1994), pickles and cake dressing (Osawa et al., 1995), and also in nutritional functional beverages (Henn and Kunz, 1996); and used of onion pomace in many snacks (Kee et al., 2000). Therefore, transformation of these wastes into wealth makes it possible for fruit and vegetable processing companies to improve their competitiveness. These residues are also the important source of antioxidants, antimicrobials, flavouring, colorants, texturizer, source of dietary fibres and proteins for food additives in the food industries. This scenario helps the fruit and vegetable processing companies to reduce their cost of treatment, and even to generate additional profits from what was previously considered waste, and thus to improve their competitiveness.

**NEED FOR AGRICULTURAL WASTE MANAGEMENT EXTENSION**

In present days, residues based on horticultural product is a critical issue which are not getting enough public/government attention and even the society doesn’t have the knowledge, noble means of conserving these products. In present days peoples are leading easy and comfortable life and naturally it encourage them to waste the horticultural products since these products are easily and readily available at reasonable prices. Thus, in accordance to the current situation waste management extension should be implemented right from the grassroots (from rural to national levels) levels in each and every sectors of agriculture. Some of the most common justifications for implementations according to Mohammadi (2006) are as follows:

1. To remain productive the horticultural sectors needs more complex changes.
2. Emergences of ongoing in production and processing defects.
3. Incorporation of industry and horticulture
4. Rising food insecurity concerns and dedications of government to eradicate it.
5. Rapid population growth; increased demand for food and fibres.
6. Productivity and efficiency concentration
7. Providing beneficiary and market safety
8. Needs for improving food safety, availability and sufficiency among nations
9. Eradication of poverty all the way through agricultural awareness, technology and socio-economic conversion

CHALLENGES AND FUTURE PROSPECT

Various challenges have been acknowledged which needed instant attention. According to Jayathilakan et al. (2012), the main aim for the utilization of any kind of residues should always be the production of high esteemed products (processed raw materials) which can meet the demands of the market and create substantial economic impacts in the market. Researcher like Adinugraha et al., (2005); Uyen and Schnitzer (2009) also agreed with Jayathilakan et al. (2012) and found that it is the most significant key characteristics in the supervision of horticultural residues, as it will deeply determine the possibility and capability of the residues in future commodity. The product quality from horticultural residues should be better or comparable to its counterparts to guarantee market demands.

Processed purified raw materials, products developed and bio-chemicals from the horticultural residues need to be immediate evaluation for toxicity and any negative impact on environment before regulations and/or applied for human consumption. Prior to human consumption, medicinal products, food additives and components derived from horticultural residues are mandatory to undergo clinical trials and toxicological assessment and later on regularised and standardised by global bodies such as Codex

The diverse species and varieties in the horticultural crops residues are the potential area which is needed to be explored for obtaining better quality of raw material for the various food and non-food industries. Limited reports were available on the quality of horticultural residues by the effects of climate, geographical location, and on the level of plant maturity. Many researchers has reported that the bioactive compound present in different crop residues are varied significantly due to environmental location (Baraldi et al., 2008; Dinchev et al., 2008), seasonal changes (Shah et al., 2010) and from different stages of plant growth (Baima 2005).

Other than the studies on horticultural residues disposal areas such as task of extension has to improve among the facilitators within the horticultural waste management system, so that farmers have access to all the available information which will help them to enhance their social, economic and cultural status. Agricultural extension education is, in the first instance, “agree cultural” development programmes between the conciliator in the horticultural waste management system. This facilitating function mainly focuses on the improvement of the relationships that assurance to be more favourable to the economic development of farmers.

Through horticultural waste management extension education and vocational training, education and training can be given to the farmers on the types of horticultural residues and its management that have to be proven potentially valuable.
CONCLUSION

Proper management and utilization of horticultural residues is eco-friendly approaches that reduce environmental problems. For many food and non-food industries, due to its resourcefulness and usefulness as raw material it will provide good and solid prospects for potential income generating commodity in future. Not only in the form of commodity for the farmers but it will also benefit the consumers by providing alternative products.

Waste management extension education should be able to enhanced “Care and Share” movement as a worldwide towards declining agricultural lose and for recycling in order to reduce more wastage lose for achieving zero emissions for long prospective by declining the agricultural lose to waste and waste to lose. Through promotion of horticultural waste management extension education in different interdisciplinary departments like horticultural, environmental studies, human studies, natural studies etc. at the undergraduate level for training the competent agents and at the higher levels like graduate and post-graduate levels for training the qualified researchers and experts that will help in the development of waste management for acquiring more rational production and for a cleaner, healthier green Earth.

REFERENCES


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Table 1: Horticultural (fruit and vegetable) wastes produced from processing, packing, distribution and consumption in different countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Vegetables</th>
<th>Fruits</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>122.19</td>
<td>473.06</td>
<td>595.25</td>
</tr>
<tr>
<td>India</td>
<td>74.88</td>
<td>146.55</td>
<td>221.43</td>
</tr>
<tr>
<td>USA</td>
<td>25.38</td>
<td>35.29</td>
<td>60.67</td>
</tr>
<tr>
<td>Philippines</td>
<td>16.18</td>
<td>6.30</td>
<td>22.48</td>
</tr>
<tr>
<td>Thailand</td>
<td>10.27</td>
<td>3.81</td>
<td>14.08</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1.07</td>
<td>3.81</td>
<td>2.28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Production (MT)</th>
<th>Fruits and Vegetables processed (%)</th>
<th>Processed F and V (MT)</th>
<th>Losses and wastage (%)</th>
<th>Waste generated (MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1376.00</td>
<td>23.00</td>
<td>136.91</td>
<td>2.00</td>
<td>31.98</td>
</tr>
<tr>
<td>India</td>
<td>2378.00</td>
<td>2.20</td>
<td>4.87</td>
<td>25.00</td>
<td>1.81</td>
</tr>
<tr>
<td>USA</td>
<td>1211.90</td>
<td>65.00</td>
<td>39.43</td>
<td>10.00</td>
<td>14.95</td>
</tr>
<tr>
<td>Philippines</td>
<td>565.00</td>
<td>78.00</td>
<td>17.53</td>
<td>10.00</td>
<td>6.95</td>
</tr>
<tr>
<td>Thailand</td>
<td>565.00</td>
<td>30.00</td>
<td>4.22</td>
<td>10.00</td>
<td>1.07</td>
</tr>
<tr>
<td>Malaysia</td>
<td>6987.70</td>
<td>80.00</td>
<td>1.82</td>
<td>80.00</td>
<td>0.68</td>
</tr>
</tbody>
</table>


Table 2: Fruits and vegetable processing wastes, its nature and its percentage.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Production (Tonnes)</th>
<th>Approximate waste (%)</th>
<th>Potential quantities of waste (Tonnes)</th>
<th>Nature of waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>1376.00</td>
<td>-</td>
<td>412.00</td>
<td>Peel, pomace and seeds</td>
</tr>
<tr>
<td>Banana</td>
<td>2378.00</td>
<td>35.00</td>
<td>832.30</td>
<td>Peel, rag and seed</td>
</tr>
<tr>
<td>Citrus</td>
<td>1211.90</td>
<td>50.00</td>
<td>606.00</td>
<td>Stem, skin and seeds</td>
</tr>
<tr>
<td>Grapes</td>
<td>565.00</td>
<td>20.00</td>
<td>-</td>
<td>Peel and core and seed</td>
</tr>
<tr>
<td>Guavas</td>
<td>565.00</td>
<td>10.00</td>
<td>-</td>
<td>Peel, stones</td>
</tr>
<tr>
<td>Mango</td>
<td>6987.70</td>
<td>45.00</td>
<td>3144.40</td>
<td>Skin, core</td>
</tr>
<tr>
<td>Pineapple</td>
<td>75.70</td>
<td>33.00</td>
<td>24.70</td>
<td>Outer leaves</td>
</tr>
<tr>
<td>Onion</td>
<td>1102.00</td>
<td>-</td>
<td>68.30</td>
<td>Shell</td>
</tr>
<tr>
<td>Peas</td>
<td>107.70</td>
<td>40.00</td>
<td>415.30</td>
<td>Peel</td>
</tr>
<tr>
<td>Potato</td>
<td>2769.00</td>
<td>15.00</td>
<td>90.30</td>
<td>Skin, core and seeds</td>
</tr>
<tr>
<td>Tomato</td>
<td>464.50</td>
<td>20.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Gupta and Joshi (2000).
**Figure 1**: Nutritional facts of different fruit residues

Source: Mani and Sethi (2000).