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Management of crop residue through various techniques

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Abstract
Keeping in view the increasing problems associated with crop stubble burning in the state of Punjab, several initiatives for its proper management have been taken up. Various departments and institutions of the Punjab government are promoting alternative uses of straw instead of burning. Rice-wheat system is a major dominating cropping system of India. High yields of the irrigated Rice-wheat system have resulted in production of huge quantities of crop residues. Burning of rice straw is common in north-west India causing nutrient losses and serious air pollutions affecting human health, climate change and global warming. To avoid straw burning, innovations in crop residue management should assist in achieving sustainable productivity and allow farmers to reduce nutrient and water inputs, and reduce risk due to climate change. Crop residues contain significant quantities of plant nutrients and their judicious application will have positive effect on nutrient management in rice wheat system. Long-term studies of the residue recycling have indicated improvements in physical, chemical and biological health of soil. Other plausible option of crop residues management lies in utilizing a portion of surplus residue are incorporate in to soil which improve soil health, increase nutrient use efficiency and minimize air pollution and other i.e. mushroom cultivation as converting of inedible crop residues into valuable food, surface mulch as conservation of soil moisture, temperature and control of weed emergence, bio-fuel and compost production. Residue decomposition in soil substantially increases the soil organic carbon and other nutrient.

Keywords: Management, physical, chemical and biological

Introduction

Crop residues are parts of the plants left in the field after crops have been harvested and threshed. The recycling of crop residues has the advantage of converting the farm waste into useful product for meeting nutrient requirement of succeeding crops. India is an agrarian country and generates a large quantity of agricultural wastes. This amount will increase in future as with growing population there is a need to increase the productivity also. Agricultural residues are the biomass left in the field after harvesting of the economic components i.e., grain. Large quantities of crop residues are generated every year, in the form of cereal straws, woody stalks, and sugarcane leaves/tops during harvest periods. Processing of farm produce through milling also produces large amount of residues. These residues are used as animal feed, thatching for rural homes, residential cooking fuel and industrial fuel (Niveta *et al.* 2014) [6]. Crop residues are a source of organic C for soil microorganisms and also contribute to plant nutrients. Crop residue retention on the soil surface, substantially reduces run-off and soil erosion and can decrease soil evaporation and land preparation costs. With the introduction of combine harvesters, more than 75% of the rice area is harvested mechanically.

Most farmers remove wheat straw for feeding the animals. However, management of the rice straw is a major challenge as it is considered to be a poor feed for the animals owing to high silica content. Combine harvester leaves behind a swath of loose rice residues, which interfere with operations of the seed drill used for planting wheat. To avoid these problem farmers burns this crop residue (90-140 Mt annually). From the farmers' point of view, burning may be seen as the most suitable method of disposing of rice straw. It is not only a cost-effective method but it acts as an effective pest control procedure (Adam John 2013) [1].

Burning of crop stubble causes the air pollution and lead to loss of huge biomass, i.e. organic carbon, plant nutrients, the entire amount of C, approximately 80–90% N, 25% of P, 20% of K and 50% of S present in crop residues are lost in the form of various gaseous and particulate matters, resulting in atmospheric pollution and global warming, but also cause adverse effect on soil properties as well as soil flora and fauna. Stubble burning also impacts human and animal health both medically and by traumatic road accidents due to restricted visibility. So, there is a need to adopt ways and options to manage this valuable resource. In this article, crop residue potential, its management options and soil properties associated with residue management etc. are discussed.

Crop residue management

In India, rice wheat cropping system produces huge quantities of crop residues. Majority of rice and wheat harvesting in North West India is combine harvester leaving residues in the field. The residues of cereal crops are mainly used as cattle feed. Rice straw and husk are used as domestic fuel, Mulching or in boilers for parboiling rice. Management of rice straw, rather than wheat straw is a serious problem, because there is very little turn-around time between rice harvest and wheat sowing and due to the lack of proper technology for recycling and the higher silica content than other crops. Several management options are available to farmers for the gainful management of crop residues are livestock feed, mushroom cultivation, incorporation, surface retention and mulching, and removing the straw. Farmers use different straw management practices as per the situation.

As livestock feed

Traditionally, the crop residues likes wheat and paddy straw in India are utilized as animal feed such as or by supplementing with some additives. However, crop residues, being unpalatable and low in digestibility, cannot form a sole ration for livestock. The rice straw is considered poor feed for animals due to its high silica content. It differs from other straws in having a higher content of silica (12-16 vs. 3-5%) and a lower content of lignin (6-7 vs. 10-12%). The nutritional value of rice straw can be upgraded by different methods. Physical, chemical and biological treatments have been used to weaken and break down ligno-cellulose bonds in crop residues, thereby increasing their nutritional value (Kamla *et al.* 2015) [5]. About 75% of wheat straw is utilized as fodder for animals, chopped in small pieces with the help of special cutting machine though this requires additional operation and investment. Rice straw stems are more digestible than leaves because their silica content is lower; therefore the rice crop should be cut as close to the ground as possible, if the straw is to be fed to livestock. To complete the nutritional requirements of animals, the residues need processing and enriching with urea and molasses, and supplementing with green fodders (leguminous/non-leguminous). More than 80% of wheat straw is still collected for its later use as an animal feed, high silica contents in paddy straw lowers its palatability for animals, (Biswas *et al.* 2006) [3] have reported that crude protein content with urea molasses mineral mixture treatment of paddy straw can be increased from 3.2% in the untreated straw to 6.4% processing of paddy straw with urea, improved the dry matter intake, digestibility and utilization of nutrients and nutritive value.

As mushroom cultivation

Use of residues in mushroom production represents a valuable conversion of inedible crop residues into valuable food, which despite their high moisture content has two to three times as much protein as common vegetables and an amino acid composition similar to that of milk or meat (Harikrishna 2013) [4]. Wheat and rice straws are excellent substrates for the cultivation of Agaricus bisporus (white button mushroom) and Volvariella volvacea (straw mushroom), two of the four most commonly grown fungi. Straw for Agaricus cultivation is usually mixed with horse manure and hay and a very high conversion efficiency of the substrate into fungal bodies is possible (Salar and Aneja 2007) [8]. Rattan (2013) [7] also showed that paddy straw though does not provide good physical structure to compost but gave a good result when mixed with wheat straw in equal quantities.

Use of Crop Residue in Bio Thermal Power Plants

Another use of rice residue that is being encouraged by various institutions and departments is the use of rice residue for generation of electricity. A 10 MW biomass based power plant at village Jalkheri, Fatehgarh Sahib with paddy straw as fuel was set up in the year 1992 (Box 4.1). The plant is operational since 2001, after the PSEB entered into a lease-cum-power purchase agreement with Jalkheri Power Private Limited (JPPL). The original system installed by BHEL i.e. firing the boiler with paddy straw in baled form, used to create innumerable problems like ash melting, snagging, super heater choking, clinkerisation, drop in boiler temperature due to moisture in the bales, etc. Hence, the fuel was changed from paddy straw to rice husk, wood chips, cotton waste, etc., in mixed form or rice husk alone to achieve the desired parameters. The total requirement of biomass is estimated to be 82,500 MT/annum at 100 % capacity utilization for optimum plant activity. Crop residues are bought from the farmers at Rs. 35 per quintal (which would otherwise have remained unutilized or burnt in the field). The farmers are being made aware of this offer through newspapers and other awareness activities. Apart from the generation of electricity for supply to state grid to meet the ever-increasing demand for energy in the state, the plant also reduces the Green House Gases (GHGs) emissions. As per Cleaner Development Mechanism (CDM) estimates, the plant would supply energy equivalent of approximately 417.9 million kWh to the grid in a period of 10 years (2002–2012), thereby resulting in total CO2 emission reduction of 0.3 million tonnes.

Incorporation of Crop Residue in the soil

Unlike removal or burning of crop residue put the adverse effect on soil climate and micro -organisms, so incorporation of straw increases soil organic matter and N, P and K contents in soil. Ploughing is the most efficient residue incorporation method (Adam John 2013) [1]. The incorporation of Crop Residues in the field is beneficial in recycling nutrients, but leads to temporary immobilization of nutrients (e.g., Nitrogen) and extra nitrogenous fertilizer needs to be added to correct the high C:N ratio at the time of residue incorporation (Singh *et al*. 2008) [9].

Production of bio-oil from Crop Residue

Bio-oil is a high density liquid obtained from biomass through rapid pyrolysis technology. It has a heating value of approximately 55 % as compared to diesel. It can be stored, pumped and transported like petroleum based product and can be combusted directly in boilers, gas turbines and slow and medium speed diesels for heat and power applications, including transportation. Further, bio-oil is free from SO2 emissions and produces low NO2. Certain Canadian companies (like Dyna Motive Canada Inc.) have patented technologies to produce bio-oil from biomass including agricultural waste.

Crop Residue as animal bedding and compost

For preparing compost, crop residues are used as animal bedding and then heaped in dung pits. It has been found that the use of paddy straw bedding during winter helped in improving the quality and quantity of milk as it contributed to animals' comfort, udder health and leg health. Paddy straw bedding helped the animals keep themselves warm and maintain reasonable rates of heat loss from the body. In the animal shed each kilogram of straw absorbs about 2-3 kg of urine, which enriches it with N. The residues of rice crop from one hectare land, on composting give about 3 tons of manure as rich in nutrients as farmyard manure (FYM). The rice straw compost can be fortified with P using indigenous source of low grade rock phosphate to make it value added compost with 1.5% N, 2.3% P2O5 and 2.5% K2O (Behera 2018) [2]. Yadvinder Singh *et al.* (2004) [10] concluded that the wheat and rice straws used to be collected for their use as cattle feed and other purposes such as livestock bedding, thatching material for houses, and fuel.

Conclusion

The recycling of crop residues has the great potential to return a considerable amount of plant nutrients to the soil. Particularly the yield stagnation consequent upon the declining soil organic carbon is a major threat to this system. Therefore it is a great challenge to the agriculturists to manage crop residues effectively and efficiently for enhancing sequestration of carbon and maintaining the sustainability of production. Different techniques as mentioned above can be used depending on type of residue and climate conditions.

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