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Agricultural Mechanization for *In-situ* Management of Crop Residue in Punjab

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Introduction

Punjab is the food stock of India. The main cropping system of Punjab is wheat and rice and about 28.9 lakh hectares of land is cultivated in paddy. About 90 per cent of wheat and paddy are harvested every year with combine. After harvesting wheat with combine, 80 per cent straw is prepared with straw combine from left crop residues.

Crop residue is defined as the non-photosynthetic vegetation and comprised of stalks, cobs and other plant parts left behind after harvesting the crops on the field. Burning crop residue causes phenomenal pollution problems in the atmosphere and huge nutritional loss and physical health deterioration to the soil. The burning of one tonne of paddy straw releases 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash and 2 kg SO_2. These gases affect human health due to general degradation in air quality resulting in aggravation of eye and skin diseases. Fine particles can also aggravate chronic heart and lung diseases. One ton of paddy straw contains approximately 5.5 kg N, 2.3 kg P_2O_5, 25 kg K_2O, 1.2 kg S, 50-70 per cent of micro-nutrients absorbed by rice and 400 kg of carbon, which are lost due to burning of paddy straw. Apart from loss of these nutrients, some of the soil properties like soil temperature, pH, moisture, available phosphorus and soil organic matter are greatly affected due to burning. Nonetheless, time available between the rice harvesting and wheat sowing is very narrow and in the range of 20-30 days. It is envisaged that appropriate strategies for *in situ* crop residue management are planned for effective implementation to enable zero burning.

Various equipments/machines such as Super Straw Management System (SMS) attached with existing combine harvester, Happy Seeder, Straw Chopper/Mulcher, Rotary

Slasher, Reversible MB Plough, Rotavator etc. have been developed and successfully demonstrated in the farmers, fields.

Availability of crop residues

In India, over 500 million tonnes of agricultural residues are produced every year. Cereal crops (rice, wheat, maize, millets) contribute 70 per cent of the total crop residues (352 million tonnes) comprising 34 per cent by rice and 22 per cent by wheat crops. Every year, Punjab produces 220 lakh tonnes of rice residues due to paddy cultivation. For timely sowing of wheat, 80-85 per cent of farmers consider setting up of burning paddy residues as a simple method. The amount of residue produced by cereals is usually high because of a high straw to grain ratio, low decomposition rate and high carbon to nitrogen ratio (C:N).

Types of crop residues

The combine harvester cut the cereal crops (rice, wheat and maize) at certain height above the ground, thereby creating two distinct straw components after harvesting:

(i) The standing stubble or anchored crop residues
(ii) Loose crop residues-big uneven heaped lines of straw over the harvested field.

It is particularly the latter that cause problem for establishing the subsequent crop.

Crop residues source of plant nutrients

Crop residues are good sources of plant nutrients, are the primary source of organic matter (as carbon constitutes about 40 per cent of the total dry biomass) added to the soil and are important components for the stability of agricultural ecosystems. About 40 per cent of the N, 30-35 per cent of the P, 80-85 per cent of the K and 40-50 per cent of the S absorbed by rice remain in the vegetative parts at maturity. Similarly, about 25-30 per cent of N and P, 35-40 per cent of S and 70-75 per cent of K uptake are retained in wheat residue.

Typical amount of nutrients in rice straw at harvest is 5-8 kg N, 0.7-1.2 kg P, 12-17 kg K, 0.5-1.0 kg S, 3-4 kg Ca, 1.0-3.0 kg Mg, and 40-70 kg Si per ton of straw on a dry weight basis. One ton of wheat residue contains 4-5 kg N, 0.7-0.9 kg P and 9.0-11 kg K. About 50-80 per cent of micronutrient cations (Zn, Fe, Cu and Mn) taken up by rice and wheat crops can be recycled through incorporated residue.

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Why farmers burn crop residues?

RICE: In rice crop, mainly combine harvester is used, which leaves huge quantity of residue inside the field. But there is little turn-around time between rice harvest, residue incorporation and sowing of succeeding crops (mainly wheat), the slow rate of decomposition of rice straw due to high silica content and low temperature. Therefore, after rice harvesting, less time is available for proper decomposition of rice residues and the establishment of next wheat crop. This causes immobilization of N in succeeding crop. Farmers do not generally consider rice straw as a suitable animal feed-due to high silica content (12-16 per cent) and fear of reduced milk yield.

Scarcity of labour, farmers hesitate to invest in cleaning the field by using a chopper. This practice also requires another operation and increases cost. Farmers in North West (NW) India have discovered burning as the cheapest and easiest way of removing large loads of residues produced by rice to establish the wheat crop rapidly after rice. Presently, more than 80 per cent of total rice straw produced is being burnt by the famers in 3-4 weeks during October-November.

WHEAT: To address the potential loss of wheat straw when combine harvester is used, a straw reaper was developed by local manufacturers in Punjab in the mid-1980s. It is tractor-pulled and chops the loose wheat straw and standing stubbles into its preferred feeding form (‘bhusa’) and collects this on the go in an enclosed trailer attached behind. Even this practice, leaving behind about 20 to 25 per cent (1.5-2.0 t/ha) wheat straw in the field. The wheat straw left on the field is also burned by farmers before preparing for rice transplanting. Alternate, crop residues should be incorporated into the soil, which helps to improve fertility status of soil.

Manual wheat harvesting is labour intensive but allows for maximum straw recovery by allowing the crop to be cut at near ground level and subsequent off-site mechanical stationary threshing which separates grain from the finely chopped wheat straw.

Management of crop residues

- Surface retention
- Residue incorporation
- Crop residues used as surface mulch

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- For production of good quality compost
- For cultivation of mushroom
- Baling and removing the straw

Surface retention of crop residues

Practice that leaves straw residues from a previous crop on the soil surface without any form of incorporation. It helps to protect the fertile surface soil against wind and water erosion and also reduced evaporation from soil surface. This method is prevalent in no-till or conservation tillage practice where at least 30 per cent of soil surface is covered with crop residues.

Farmers sow wheat crop in standing residues of rice with Happy Seeder, this practice reduces the land preparation costs. Higher weed infestation is observed in field with residues retention under zero tillage, which requires greater use of herbicides, bringing possible problems of herbicide-resistance. Soil compaction under zero-tillage (ZT) responsible for restricted oxygen supply to root zone, which adversely affected vigorous plant growth. Use of Happy Seeder reduces land preparation costs and retention of rice residues helps to increase the organic matter status of soil.

Residue incorporation in soil

Crop residue is incorporated completely or partially into soil mostly by ploughing. Above-ground portion is chopped into small size and incorporated. Incorporation of crop residue increases soil organic matter and nutrient recycling. Incorporation of crop residues on surface soil helps for carbon sequestration because residue incorporation helps in addition of biomass and increase in soil organic carbon content. No emission of GHS as compared to burning of residues. Incorporation of residues leads to temporary immobilization of nutrients (Nitrogen) and the high C:N ratio which needs to be corrected by applying extra fertilizer N at the time of residue incorporation. A crop grown immediately after the incorporation of residues suffers from N deficiency caused by microbial immobilization of soil and fertilizer N in the short term. Rice straw can be managed successfully *in-situ* by allowing sufficient time (10-20 days) between its incorporation and sowing of the wheat crop to avoid N deficiency due to N immobilisation. The practice of *in-situ* rice straw incorporation as an alternate to burning has been adopted by only a few farmers because of high incorporation costs and energy and time intensive. Application of rice residue to wheat typically has a small effect on wheat yields during the short term of 1-3 years but the effect appears in the fourth year with the incorporation of straw.

Crop residues as surface mulch in other crops

The beneficial effects of this practice to improve crop yields at comparable irrigation regimes and saving of irrigation water and fertilizer nitrogen at comparable yields have been reported in several wide row crops- maize, sugarcane, sunflower, soybean, cotton, turmeric, potato and chillies by reducing the evaporation (E) component of the ET and acting as barrier to vapour flow and moderating soil temperature. The response is more under high temperature, low rainfall areas and on coarse texture soils. Higher soil water in the profile, especially the root zone, in the mulched plots caused better stand establishment and early seedling vigour. More favourable soil temperature and higher water content under mulched than un-mulched soil increases mineralization of soil N. Due to the scarcity of labour and high cost involved in collection and applying straw mulch, this technology has not become popular with the farmers.

Suppression of weeds with crop residue mulch because of:

a) Physical presence on the soil surface as mulch.

b) Restricting solar radiation reaching below the mulch layer.

c) Direct suppression caused by allelopathy.

d) It reduces herbicide requirements and weed competition for nutrients and water.

Impact of crop residue management on pest and disease pressure: Retaining residue as mulch in no-till system scan further increase soil-borne diseases (Seed rot, seedling blight etc.) because of the lack of soil disturbance and retention of crop stubble on the soil surface. The crop residue can serve as an inoculums source and maintain favourable moisture and temperature conditions in the top 10-15 cm of soil where the pathogens are most active. In addition to residue-borne diseases, mulch can also favour the survival of some soil-borne pathogens because the pathogens are protected from microbial degradation by residence within the crop debris. On the other hand, mulch may suppress other soil-borne pathogens, because it increases the population of soil micro and meso-fauna, which offer potential for biological disease control as many of these species feed on pathogenic fungi. Periodic residue incorporation in a no-till system can inhibit pathogen growth by forcing it into a place with insufficient air and light. Crop residue as mulch has the potential to control weed growth, thereby suppressing the possible negative effect of increased weed intensity, because weeds also acts as alternate hosts for the survival of pathogen.

Preparing good quality compost

Rice straw can be converted into high-value manure of better quality than FYM and its use, along with chemical fertilizers, can help sustain or even increase the agronomic yield. During composting rice straw can be fortified with P using indigenous cheap source of low grade rock phosphates to make it value added compost with 1.5% N, 2.3% P_2O_5 and 2.5% K_2O. The rice residue can be composted by using it as animal bedding and then heaping it in dung heaps. Each kg of straw can absorb about 2-3 kg of urine from animal shed. The residues of rice from one hectare give about 3.2 tonnes of manure as rich in nutrients as FYM. But farmers do not appreciate the collection of the residues manually for this purpose.

Mushroom cultivation

Paddy mushroom (*Volvariella volvacea*) is also known as Paddy straw or Chinese mushroom. Four crops of this variety can be obtained from April to August. Process the paddy straw (not more than 1 year old) into bundles each weighing 1 kg approx. Tie the bundles at both ends and cut the unequal protruding parts of the bundles. Wet the bundles for 16-20 hours in clean water. Drain off excess water by placing the bundles on sloping surface. Beds are laid on slightly raised platform. One bed comprises of 22 bundles arranged in 4 layers of 5 bundles each, with two loose bundles at the top. 300 g of spawn should be used per bed (75g/layer). Beds should be watered twice a day except for the first 2-3 days after laying. Adjust the watering according to the site and local environmental conditions. Rice straw is stacked into small bundle and *Pleurotus sp*. is also grown for edible mushroom. Rice straw is cheap and easily available substrate for mushroom cultivation.

Baling and removing the straw from field

After bailing crop residues can also be used for paper and ethanol production. Also used for livestock feed, fuel, building materials, livestock bedding, bedding for vegetables cultivation and mulching for orchards and other crops.

Other ways to management of paddy straw

Using paddy straw treated with urea for dairy cattle

To meet the foodstuff of animals, they need a balanced diet. Green fodder, straw, distribution, scrap of scales etc. are part of the diet of animals. Apart from this, paddy straw can be modified with urea and used for dairy cattle. This also takes care of paddy straw.

Fertilizer management practices for higher productivity

No-till systems with surface residue often exhibit suppressed yields due to lesser N availability because of slower soil N mineralization, greater N immobilization, denitrification and NH_3volatilization, particularly in the early part of the growing season compared with conventional-till systems. Reducing fertilizer N contact with the straw by drilling the fertilizer below the soil surface (about 5 cm beside/below the seed row) to minimize immobilization and volatilization may increase N use efficiency in wheat. Greater immobilization in reduced and no-till systems can enhance the conservation of soil and fertilizer N in the long term, with higher initial N fertilizer requirements decreasing over time because of the build-up of a larger pool of readily mineralizable organic N. This transition period may vary from 4-6 years, during which band placement of nutrients below the residue-covered surfaces becomes very important.

Machines developed for crop residue management

Happy seeder

This machine has been upgraded by attaching a press wheel assembly with normal happy seeder. This machine can be used for sowing of wheat in combine harvested paddy fields after cutting and spreading of standing stubbles with PAU Straw Cutter-cum-Spreader. This happy seeder uniformly place and press the chopped paddy straw in inter row area as a mulch, which facilitate better germination, emergence and vigorous initial crop establishment. With happy seeder machine, wheat can be sown directly in the field (7-9 tonnes per hectare straw) of combine harvester rice. This machine can run with 45 horse power tractor and its capacity is 0.6-0.75 acres per hour. It costs about Rs. 125,000/ -. With this machine, the yield of wheat increases by about two quintals per acre, reduces the cost of fertilizers, and simultaneously saves time and expenses and wheat sowing can be done in a timely manner.

Zero-till drill machine

This machine can be run after running a four-wheeler or a baler. There is no need to mix the straw with soil in order to run it. Its working capacity is 0.6-1.0 acres per hour and it can be run with 45 horsepower tractors. It costs about Rs. 70,000/-.

Baler

This machine collects paddy straw and makes rectangular or spherical bales. Rectangular bales balers are being used more in Punjab. This machine makes paddy bales in the field, which can be easily collected from the field. This machine can be operated with a 45 horsepower tractor. These straw bundles can be used for making canes, composting, packing, brick kiln and electricity. At present, there are seven power generating plants in the state using paddy straw. These plants buy bales at a rate of Rs 1000-1500 per tonne. Farmers can sell these bales in power plants. The average weight of the bales is 15-35 kg. This machine makes bales out of 6-7 acres of land in one day. The price of the baler is approximately Rs. 10,00,000/- and the cost of the rack is about Rs. 3,00,000/-.

Chopper-cum-Spreader

After running the chopper, apply irrigation to the field and mix it with soil with rotavator. In this way the exposure to soil cause complete and fully decomposing the residues. 20 kg per acre urea can be broadcast for faster decomposing the residues. Depending on the type of soil, after *rauni* the required optimum moisture is comes within 2-3 weeks in the field. Wheat can be sown with a normal drill when necessary. If the last irrigation is given to the paddy crop a few days before the harvest, after running the chopper, the straw can be mixed in the soil. This machine can be run with 45 horse power tractor and its price is approximately Rs. 80,000/-.

All these measures are helpful to farmers to utilize this precocious product in different ways and to reduce the pollution problem. Hope that this article is helpful to every living body to reduce the burning problem and air pollution. This also fulfills the aim of Green India- Pollution Free India.