Quarterly news bulletin – September 2018

Clearing crop stubble – from problems to fuel, fertilizer, and rural livelihood

Most families in our region (south-Asia) live in villages and are at least partially dependent on agriculture for their livelihood, hence the main activities correspond to the farming seasons. The prevailing farm practices in turn have impacts on people and on the environment.
The summer (*kharif*) grain crop has just been (or is being) harvested and the fields will soon have to be cleared for preparation towards sowing the winter (*rabi*) crop.

Problems
Clearing the fields of post-harvest plant remnants such as paddy stalks can be difficult. Manual cutting is very laborious. Ploughing the stubble back into the fields, to degrade in situ, would be good for the soil, but requires equipment that is expensive and for which financial assistance would be essential. Further, the short period available between the completion of the summer paddy harvest and preparation for the winter wheat crop, often less than three weeks, pushes farmers to use a quick method. Farmers may also be unaware of the detrimental effects of setting fires in the fields[1].
The cheapest and quickest option is burning the drying stubble in the fields (Fig.1, courtesy *Down to Earth*).

Emissions from the burning residues contribute to air pollution locally, and in neighbouring windward regions. This has become excessive in industrial and urban locations[2] where factory and vehicular emissions are already causing unhealthy pollution. The National Green Tribunal (NGT) had therefore imposed a ban on stubble-burning and proceeded to fine farmers for violations. Nevertheless, without viable alternatives, stubble-burning has continued.

Worthwhile alternatives
Crop stubble can be used for producing fuel and/or nourishing the soil; these benefits could justify the costs of clean stubble removal.

Conversion to mulch
Efficient machinery, for example, the rotary mulcher (Fig.2) can be used for cutting and pulverising crop-stalks and grinding them into the soil to form mulch. This is beneficial for croplands, as the mulch enriches the soil with the nutrients contained in the plant remnants, and also helps to retain water. However, the costs of the required

[1] Stubble-burning is also estimated to cause losses of 6 -7 kg of nitrogen, 1 – 1.7 kg of phosphorus, 14 – 25 kg of potassium, and 1.5 kg of sulphur, per tonne of soil.
[2] Estimates indicate a 70% spike in CO_2 levels and increases of 7% and 2.1% in CO and NO_2, respectively, in the post-harvest period.

equipment required are prohibitive to most farmers.

Fortunately, there are now subsidies for purchasing equipment for harvesting, field-clearing, and re-sowing croplands, such as the super straw management system (or Super SMS)[3]. Last month (August '18), the NGT directed the Secretary of the Ministry of Agriculture to submit a status report on providing infrastructural assistance, including providing machinery to poor and marginal farmers. The central government is now providing financial support to state governments for subsidizing crop residue management equipment. The government of Punjab has been given a first instalment of InR 269 crore (≈ US$ 37.36 million) to assist primary agriculture cooperative societies (PACS), farmers' clubs (with at least eight members), and even individual farmers, with buying equipment. The subsidies range from 50% for individuals to 80% for PACs.

Conversion to fuel

If not mulched, straw can be converted to forms that are usable as fuel. The payment for such fuel-feedstock (e.g. rice straw) should, of course, compensate farmers for the costs of stubble-cutting and packing in bales. Likewise, the price realizable for the fuel produced would have to account for the costs of transport, and the conversion processes. If straw-to-fuel conversion were economically and operationally viable, there could be renewable sources of energy and of organic fertilizer, while providing farmers with an alternative to stubble-burning.

Direct use of dried rice/wheat plant residues or straw, say as a boiler fuel, is not easy because of the low energy content (e.g. that of rice straw is around 14 MJ per kg at 10 percent moisture content), high ash content (between 10-17% for rice straw, and around 3% for wheat straw), high alkali content (that causes slagging and corrosion of boilers).
However, converting straw to usable fuel is possible; there are two sets of options that are now being implemented in India:
(1) *densification/torrefaction for conversion to usable solid fuel* – either (a) *biomass pellets/briquettes*, or (b) *torrefied pellets/briquettes*, for fuelling heating processes and/or generation of electricity (when co-fired along with coal), or
(2) *fermentation/methanation for conversion to fluid fuel* (where water supply is adequate) – either (a) *ethanol*, or (b) *methane*, with (c) *effluents as fertilizer*.

(1) *Solid fuel* –

(a) Pellets/briquettes are compacted forms of biomass that improve its value as fuel, i.e., the heat derivable per unit of mass is increased (as the mass to be transported is reduced) when straw is compressed to pellets or briquettes. Agro-residue pellets are small and smooth (Fig.3a), whereas briquettes are larger – bar-shaped or cylindrical, possibly with cracks (Fig.3b). The formation of pellets requires higher pressure than that for briquettes, so that pellets are denser and harder.

(b) Torrefied agro-residues – Torrefaction is a process that involves the heating of biomass in the absence of oxygen at high temperatures (typically 200 to 400°C). During torrefaction, combustible gas is released, which can be utilised for process heat. The resulting torrefied

[3] Each Super SMS has eight attachments – combine harvester, happy seeder, paddy-straw chopper, rotary slasher, shrub master, rotavator, hydraulic reversible M.B. plough, and zero-till seed-cum-fertiliser drill.

agro-residues are superior to ordinary biomass pellets/briquettes, as their calorific value is higher and they are also less likely to degrade or absorb water.

Bio-fuels are preferable to other renewable sources with diurnal and seasonal variability (such as solar and wind power), because they can be scheduled as required by the load, without battery storage or back-up provision. But firing biomass-pellets along with coal has been found more economical and efficient than in dedicated biomass plants. India's Central Electricity Authority (CEA) had therefore issued an advisory to all states and union territories across the country, asking that thermal power plants be fired with 5%-10% of agro-residue-based fuel. The National Thermal Power Corporation (NTPC) conducted a pilot project on the use of straw pellets. It has this year initiated a programme to use some agro-residue-based fuel along with coal. Tenders have been called for the procurement of 1,000 metric tonnes/day of agro-residue-based fuel for power generation at the 2,650 MW Dadri power plant in the National Capital Region. Currently (2018-20), a maximum price of InR 5,500 (≈US$ 76) per metric ton of pellets and InR 6,600 (≈ US$ 91) per ton of torrefied pellets/briquettes, has been specified. To draw greater participation, NTPC has allowed the participation of bidders without prior experience, and has divided the tender into smaller lots of 20 metric tonnes per day.

(2) *Bio-methane/bio-ethanol* –
Where water-supply is adequate for the process requirements, straw (like other ligno-cellulosic biomass) can be converted to ethanol (C_2H_5OH) or to methane (CH_4), with effluents usable as organic fertilizers.

(a) Ethanol – The high cellulosic- and hemi-cellulosic- content in rice straw can be hydrolysed into fermentable sugars. But pre-treatment – pulverization and enzymatic treatment (with an enzyme derived from mould isolated from rotted rice straw residues), is required to improve the efficiency of the process.

(b) Methane – Substrates of pulverized straw and water can be decomposed in a series of bacterial actions during anaerobic (i.e. without oxygen) digestion. Methane is one of the final products of the digestion process, but it has to be separated from the others (water vapour and carbon dioxide, and trace amounts of hydrogen sulphide etc.), before it is usable as an efficient fuel for process heating and even electricity generation.

(c) Fertilizer – The effluent material from biomass-digestion is rich in nitrogen, making it useful as organic fertilizer. Additionally, paddy-straw is also a natural source of silica - for strengthening the immunity of the plant, and for controlling arsenic absorption. Unfortunately, such manure takes longer to increase output than chemical inputs, so that the demand and corresponding prices commanded are not commensurate with its actual value.

There are already biomass-fuelled power plants in the state of Punjab. However, MoUs have recently been signed for plants at which paddy-straw alone will be converted to bio-ethanol, or bio-gas (methane), or bio-CNG (compressed natural gas). Hindustan Petroleum Corporation Ltd (HPCL) will be producing bio-ethanol for blending with petrol and diesel, at a plant in Nasibpura village (Talwandi Sabo Tehsil, Bathinda district). Indian Oil Corporation (IOCL) has plans for setting up several plants for bio-CNG; sites in Sangrur, Bathinda, and Nabha districts have been identified. Verbio India Private Limited (of Germany) intends producing bio-CNG at a plant in Bhutalkalan village (Leharagga tehsil, Sangrur district). Rika Biofuel Development Limited, through Invest Punjab, intends setting up biogas/bio-CNG plants.

Regarding "rice-straw to bio-fuel and manure", the plant already in operation at Panchanwali village (Fazilka district), established and run by Sampurn Agri Ventures Pvt. Ltd. (SAVPL), is noteworthy. This integrated plant processes paddy straw for conversion to methane for fuelling electricity generation, while also using the effluents for producing fertilizers.

The processing units include paddy-straw preparation – collection (Fig.4a), pulverization and aspiration (Fig.4b,c), substrate preparation - including blending with appropriate amounts of liquid extracted from the spent slurry and feeding the biogas-reactors, biogas production through anaerobic digestion in three reactors, including one continuously stirred tank reactor (Fig.4d), drying and packaging effluents, at times with additives, for fertilizer (Fig.4e), and scrubbing hydrogen sulphide from the gas (Fig.4f) for powering electricity generation (Fig.4g). (Photographs: Courtesy SAVPL).

In contrast with IEI-Asia's field demonstrations[4] (described in earlier newsletters), the "waste to fuel" discussion in this newsletter focuses on much larger scales, and with both wet and dry processing of residues. Viable processing units necessitate appropriate magnitudes, with corresponding arrangements for adequate feedstock procurement and pre-processing, the installation and maintenance of processing equipment (requiring power), and finally, sale of the products. With such integrated units, there would be livelihood linkages – backward (collection and transport of agro-residues in farming regions) and forward (use of the process-heating fuel and/or electricity in production units).

*Thus, alternative **integrated "stubble-to-fuel&manure" options afford vast potential for creating rural employment opportunities, improving soil-fertility, and increasing fuel supply, while simultaneously making for a cleaner environment.***

Antonette D'Sa,
IEI-Asia, September 2018

[4] At (IEI-Asia's) field projects, biogas was generated from substrates of plantation and/or cattle wastes, at the level of groups of farming families, with the gas used for fuelling their cook-stoves, and in one case for powering electricity for the village.