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Research Article

Management of Crop Residue for Sustaining Soil Fertility and Foodgrains Production in India

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Abstract

India is facing various challenges in agriculture sector for sustaining soil fertility and foodgrains production, besides environmental degradation and food security of the country in the event of ever increasing demands of foodgrains production with limited cultivable land. Cultivable land and maintaining its soil are one of the major tasks which supports about 17.6% of its population and leads to fact that, our natural resources are under considerable strain. Foodgrains are a major source of energy and are thus are vital for food and nutritional security. As such, foodgrains would continue to be the main pillar of food security and out of various crops grown, rice, wheat, and pulses etc. are still part of the staple diet of rural population. However, indiscriminate use of natural resources and over use of chemical and fertilizers etc. foodgrain production may stagnate in future. Besides, technological advances and use of machinery for crop harvesting leave behind large quantities of crop residues, which is burnt by farmers as cheap and easiest method with misconception that, burning of crop residues enhances soil fertility and helps in control weeds, insects and pests. From various studies, it is concluded that burning of crop residues result in heavy loss of soil nutrient, emits large amount of submicron aerosols and trace gases like Carbon dioxide (CO_2), Sculpture dioxide (SO_2), Carbon mono-oxide (CO) and smoke, thereby posing problem to environment and human health hazards along with creating scarcity of fodder, as well as, increase in price of fodder.

As per Ministry of New and Renewal Energy (MNRE), about 500 Mt of crop residues are generated annually in India, used as animal feeding, soil mulching, bio-manure making, thatching for rural homes and fuel for domestic and industrial uses. As such, crop residues have tremendous value, however, a large portion of the residues (about 93 Mt) is burnt on-farm, primarily to clear the field for sowing of the successive crop and it is practiced particularly, in mechanized rice-wheat cropping system. Such practice is predominant in States, namely, Haryana, Punjab, Uttar Pradesh and West Bengal.

In view of above, efforts were made to collect the data and suggest various technical and policy options for crop residue management to prohibit crop residue burning, enhancing soil fertility besides prevention of environmental degradation. The major recommendations includes, incorporation of crop residue in to the soil, adoption suitable crop rotation as recommended by ICAR or in Soil Health Care provided to the farmers, promotion of alternate competitive methods of utilizing residues in Small Scale Industries (SSI) for use of crop residue/rice straw in paper/board/panel and packing material and biomass power plants establishment in Public Private Partnership (PPP) mode to ensure economic return to the farmers and sustaining soil fertility and foodgrains production, besides prevention of environmental degradation in the country.

Keywords: Crop Residues; Incorporation, Interventions; Conservation Agriculture

Introduction

India is facing various challenges in agriculture sector for sustaining environmental degradation and food security of the country; of which, meeting the ever increasing demands of foodgrain production with limited cultivable land is one of the major tasks.

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As per available estimates {Directorate of Economic and Statistic, DAC and FW, MoA and FW (Final estimates-2012-13)} India produced about 93.51 million tons (Mt) of wheat, 105.24 Mt of rice, 22.26 Mt of maize, 16.03 Mt of millets (jowar, bajara, ragi, and small millet), 341.20 Mt of sugarcane, 7.79 Mt of fiber crops (jute, mesta, cotton), 18.34 Mt of pulses and 30.94 Mt of oilseed crops. Out of various crops grown, rice, wheat, and pulses are still part of the staple diet of most of the rural population and these crops are preferred by farmers since they provide higher economic return. It is but natural that a huge volume of crop residues is produced both on-farm and off-farm. It is estimated that approximately 500-550 Mt of crop residues are produced per year in India. Multipurpose uses of crop residue include, but are not limited to, animal feeding, soil mulching, bio-manure, thatching of rural homes and fuel for domestic and industrial use. Thus, crop residues are of tremendous value to the farmers. Despite the known of its benefit, growers' burn, a significant portion of the residues on-farm primarily to clear the field for sowing of the succeeding crop. The problem of burning of crop residues is intensifying in recent years due to shortage of human labour, high cost of removing the crop residues from the field and mechanized harvesting of crops. The residues of rice, wheat, cotton, maize, millet, sugarcane, jute, rapeseed-mustard and groundnut are typically burnt on-farm across different states of the country. The problem is more severe in the irrigated agriculture, particularly in mechanized rice-wheat system of the north-west India. It is paradox that burning of crop residues and scarcity of fodder coexists in this country simultaneously.

As per available estimates, burning of crop residues is predominant in four States, namely, Haryana, Punjab, Uttar Pradesh and West Bengal. During recent years burning of crop residues results in scarcity of fodder and simultaneously increases in price of fodder prevailed across the country. Conservation Agriculture (CA) offers a good promise for management of the crop residues in a productive and profitable manner by adoption of conservation agriculture-based technologies. With the adoption of CA based technologies these residues can be used for improving soil health, increasing crop productivity, reducing pollution and enhancing sustainability and resilience of agriculture. Resource Conserving Technologies (RCTs) involving no or minimum tillage, direct seeding, bed planting and crop diversification with innovations in residues management are the possible alternatives to the conventional energy and input-intensive agriculture.

The gravity of the situation demands that a comprehensive policy package of technical and policy interventions to promote competitive uses of crop residues in the context of conservation agriculture and also to prevent on-farm burning. Accordingly, an attempt has been made to collect data base on this issue and suggest the pro-active measure to address the issue by identification of major crop residues generating States, extent of crop residue burning, its impact, multiple uses of crop residues and mobilization of financial resources from State Sector/Central Sector Schemes/Programmes to ensure its management through resource conservation technology, besides bringing suitable law and legislation for eradication of crop residue burning etc.

Review of scenario of crop residues

As per Directorate of Economics and Statistics, MOA and FW, DACFW, New Delhi (final estimate-2015-16), Rice are cultivated in about 43 million ha. area, wheat in about 30.0 million ha. and sugarcane in about 5.0 million ha. State-wise detail of area covered under rice, wheat, sugarcane and crops prone to burning in India are given in Annexure-I. Rice and wheat crops were earlier harvested manually, and crop residue thereof was utilized as cattle feed and also for rope making etc. Now, due to mechanization these crops are harvested mechanically, leaving considerable stubble in the field which is burnt by farmers to prepare their farms for sowing of next crops.

Ministry of New and Renewable Energy (MNRE, 2009), Govt. of India has estimated that about 500 Mt of crop residues are generated every year as per state-wise details given in Annexure-II. There is a wide variability in the generation of crop residues and their burning. Generation of crop residues is highest in Uttar Pradesh (60 Mt), followed by Punjab (51 Mt) and Maharashtra (46 Mt). Among different crops, cereals generate maximum residues (352 Mt), followed by fibers (66 Mt), oilseeds (29 Mt), pulses (13 Mt) and sugarcane (12 Mt). The cereal crops (rice, wheat, maize, millets) contribute 70%, while rice crop alone contributes 34% to the crop residues. A sugarcane residue consisting of tops and leaves generate 12 Mt, i.e., 2% of the crop residues in India. Analysis of state-wise data on crop residue generated, residue surplus and burnt annually indicates that about 140.84 Mt. of crop residue are surplus and about 92.81 Mt. of crop residues are being burnt across the India annually. Crop residues are primarily used as bedding material for animals, livestock feed soil mulching and thatching of rural houses. The major adverse effects of crop residue burning are as under:

Sl. No.	Name of States	Area under major cereal crops and sugarcane			
		Rice	Wheat	Sugarcane	Crops prone to residue burning
	Andhra Pradesh	3628.0	8.0	196.0	Rice and Sugarcane
	Assam	2488.2	33.9	28.9	In jhum areas, plants and bushes are burnt
	Bihar	3298.9	2207.7	250.3	Rice, wheat and Sugarcane
	Chhattisgarh	3784.8	101.2	13.5	Rice
	Gujarat	701.0	1024.0	176.0	Rice and wheat
	Haryana	1215.0	2497.0	101.0	Rice, Wheat and Sugarcane
	Himachal Pradesh	76.9	364.2	1.9	No crop residue is burnt
	Jammu and Kashmir	261.7	290.0	0.0	No crop residue is burnt
	Jharkhand	1414.5	164.3	6.7	No crop residue is burnt
	Karnataka	1278.0	225.0	425.0	Rice and Sugarcane
	Kerala	197.3	0.0	1.7	No crop residue is burnt
	Madhya Pradesh	1882.6	5300.0	59.5	Rice and wheat
	Maharashtra	1557.0	773.0	933.0	Rice and Sugarcane
	Odisha	4022.8	1.0	14.5	No crop residue is burnt
	Punjab	2845.0	3512.0	83.0	Rice, Wheat and Sugarcane
	Rajasthan	125.6	3063.2	5.5	No crop residue is burnt
	Tamil Nadu	1493.1	0.0	347.2	Rice and Sugarcane
	Uttarakhand	262.8	358.1	109.9	Rice and wheat
	Uttar Pradesh	5861.0	9734.0	2212.0	Rice, Wheat and Sugarcane
	West Bengal	5444.3	321.6	16.1	Rice
	Others	915.4	25.1	17.2	No crop residue is burnt
Total		42753.9	30003.3	4998.9	
Total (million ha.)		42.75	30.00	4.99	

Annexure-I: State-wise major cropped area under Rice, Wheat and Sugarcane – Crops prone to residue burning.

(Area in thousand ha.)

Source: Directorate of Economics and Statistics, MOA, DAC, New Delhi (final estimate-2012-13).

a. **Loss of nutrients:** It is estimated generally crop residues of different contains 80% of Nitrogen (N), 25% of Phosphorus(P), 50% of Sulphur (S) and 20% of Potassium(K). it is also estimating that burning of 1 tonne of crop residue account for loss of 5.5 Kg Nitrogen, 2.3 Kg phosphorus, 25 Kg potassium and 1.2 kg sulphur besides, complete loss of organic carbon and polluting atmosphere. If the crop residues are incorporated or retained the soil itself, soil gets enriched, particularly with organic carbon and N.

b. **Impact on soil properties:** Heat from burning residues elevates soil temperature causing death of beneficial soil organisms. Burning of crop residues immediately increases the exchangeable NH_4 + - N and bicarbonate extractable P content, but there is no build up nutrients in the soil profile. Frequent residue burning leads to complete loss of microbial population, though the effect is temporary, as the microbes regenerate after a few days. Repeated burning in the field also reduces level of N and C and potentially mineralizable N in the upper (0-15 cm) soil layer.

c. **Emission of Green House Gases (GHG):** Burning of residues emits a significant amount of Green House Gasses (GHGs). About 70%, 7% and 0.7% of C present in rice straw is emitted as carbon dioxide (CO_2), carbon monoxide (CO) and methane ($CH_{4)}$, respectively, while 2% of N in straw is emitted as nitrous oxide (N_2O) upon burning.

S.N.	States	Residue generation*	Residue surplus*	Residue burned$
	Andhra Pradesh	43.89	6.96	2.73
	Arunachal Pradesh	0.40	0.07	0.04
	Assam	11.43	2.34	0.73
	Bihar	25.29	5.08	3.19
	Chhattisgarh	11.25	2.12	0.83
	Goa	0.57	0.14	0.04
	Gujarat	28.73	8.90	3.81
	Haryana	27.83	11.22	9.08
	Himachal Pradesh	2.85	1.03	0.41
	Jammu and Kashmir	1.59	0.28	0.89
	Jharkhand	3.61	0.89	1.10
	Karnataka	33.94	8.98	5.66
	Kerala	9.74	5.07	0.22
	Madhya Pradesh	33.18	10.22	1.91
	Maharashtra	46.45	14.67	7.42
	Manipur	0.90	0.11	0.07
	Meghalaya	0.51	0.09	0.05
	Mizoram	0.06	0.01	0.01
	Nagaland	0.49	0.09	0.08
	Odisha	20.07	3.68	1.34
	Punjab	50.75	24.83	19.65
	Rajasthan	29.32	8.52	1.78
	Sikkim	0.15	0.02	0.01
	Tamil Nadu	19.93	7.05	4.08
	Tripura	0.04	0.02	0.02
	Uttarakhand	2.86	0.63	0.78
	Uttar Pradesh	59.97	13.53	21.92
	West Bengal	35.93	4.29	4.96
	Total	**501.73**	**140.84**	**92.81**

Annexure-II: State-wise crop residue generated, residue surpluses and burned.

(Crop Residue in Mt.)

Source: * Ministry of New and Renewable Energy (MNRE, 2009), Govt. of India, New Delhi

$ Pathak Himanshu., *et al.* (2010), Senior Scientist, Center for Environment Science and Climate Resilient Agriculture, IARI, New Delhi.

d. Emission of other gases: Crop residue burning is a potential source GHSs and other chemically and irradiative important trace gases and aerosols such as CH_4, CO, N_2O, NO_X and other hydrocarbons. Besides, burning of crop residue also emits large number of particulates that are composed of wide variety of organic and inorganic species. These gases are of major concern for their global impact and may lead to increase in the levels of aerosols, acid deposition, increase in troposphere ozone and depletion of the stratospheric ozone layer. These may subsequently undergo trans-boundary migration depending upon the wind speed/direction, reactions with oxidants like OH, leading to physico-chemical transformation and eventually wash out by precipitation. Many of the pollutants found in large quantities in biomass smoke are known or suspected carcinogens and could lead to various air borne/lung diseases.

Crop residue burning is mainly in the States/areas having Rice-wheat cropping system with adequate irrigation facility and such crops are now harvested by combine harvester and other heavy machines. However, because of increased mechanization, particularly the use of combine harvesters, declining numbers of livestock, long period required for composting and unavailability of alternative economically viable solutions, farmers are compelled to burn the residues. The number of combine harvesters in the country, particularly in the Indo-Gangetic Plains (IGP) has increased dramatically, from nearly 2000 in 1986 to over 10000 in 2010. The North-western part (Punjab, Haryana and Western Uttar Pradesh) has about 75% of the cropped area under combine harvesting. Combine harvesters are used extensively in the central and western Uttar Pradesh, Uttarankhand part of Mahdya Pradesh and Bihar due to labour shortage, high wages during harvesting season, ease of harvesting and threshing and uncertainty of weather. On using combine harvesting; about 80% of the residues are left in the field as loose straw that finally ends up being burnt on farm. There are some other misconception/reasons behind intentional burning of crop residues like, soil fertility enhancement, pest and weed management. It also provides a fast way of controlling weeds, insects and diseases, both by eliminating them directly or by altering their natural habitat. The time gap between rice harvesting and wheat sowing, is only 15-20 days in north-west India. In this short duration, farmers prefer to burn the rice straw on-farm instead of harvesting it for fodder or any other use. The latter options also involve a huge transportation cost. As on-farm burning crop residue is predominant in most part of India, and accordingly a National Policy for Management of Crop Residue (NPMCR-2014) was formulated and circulated to states for adoption with following objectives [1-4].

Objectives

The major objectives of the study are:

- **a.** Prevention of burning of crop residue by promotion of optimum utilization and management of crop residue to ensure loss of invaluable biomass, nutrients and minerals;
- **b.** Promotion of mechanization i.e. baling/binding machines, combine harvester with reaper, mulchers, choppers, happy seeder, rotavators etc. to ensure minimum loss of crop residue while harvesting and its incorporation to improve soil fertility;
- **c.** Multiple/competitive use of crop residue like biomass; power generation, packing material, utilization for paper/board/panel industry and its uses in biogas generation/composting and mushroom cultivation to ensure monetary compensation to farmers;
- **d.** Promote private-public participation in establishment of industry/factory for multiple uses of crop residue and capacity building and training for its effective utilization and management; and
- **e.** Advising for formulation of suitable law and legislative/policy measures to curb burning of crop residue.

Options for utilization and management of crop residue

The utilization of crop residues varies across different states of the country. Traditionally crop residues have numerous competing uses such as animal feed, fodder, fuel, roof thatching, packaging and composting. The residues of cereal crops are mainly used as cattle feed. Rice straw and husk are used as domestic fuel or in boilers for parboiling rice. Farmers use crop residues either themselves or sell it to landless households or intermediaries, who further sell them to industries. The remaining residues are left unused or burnt on-farm. In states like Punjab and Haryana, where crop residues of rice are not used as cattle feed, a large amount is burnt on-farm. Sugarcane tops are either used for feeding of dairy animals or burnt on-farm for growing next crop. Residues of groundnut are also burnt as fuel in brick kilns and lime kilns, whereas residues of cotton, chilli, pulses and oilseed crops are mainly used as fuel for household needs. The shells of coconut, stalks of rapeseed and mustard, pigeon pea and jute and mesta, and sunflower are used as domestic fuel. The surplus residues ie total residues generated minus residues used for various purposes, are typically burnt on-farm.

Result and Discussion

As per available estimates, burning of crop residue is predominant in four states, namely; Haryana, Punjab, Uttar Pradesh and West Bengal. It os also estimated that burning of one tone of rice straw accounts for loss 5.5 kg Nitrogen, 2.3 kg Phosphorus, 25 kg Potassium and 1.2 kg sulphur, besides organic carbon. Generally, crop residues of different crops contain 80% N, 25% of P, 50% S and 20% K. Further, heat generated by rice straw burning penetrates into the soil, leading to loss of moisture and useful microbes, thus, adversely affect soil properties. High cost of collection of left over crop residue and lack of economically viable options to utilize this valuable bio- resources has been suggested in NPMC and being funded under ongoing schemes of GOI too.

Incorporation of crop residues in to soil or retention on surface has several positive influences on physical, chemical and biological properties of soil. These practices increase hydraulic conductivity and reduce bulk density of soil by modifying soil structure and aggregate stability. Mulching with plant residues raises the minimum soil temperature in winter due to reduction in upward heat flux from soil and decreases soil temperature during summer due to shading effect. Retention of crop residues on soil surface slows the runoff by acting as tiny dams, reduces surface crust formation and enhances infiltration. The channels (macro pores) created by earthworms and old plant roots, when left intact with no-till, improve infiltration to help reduce or eliminate runoff. Reduced evaporation from the upper strata of soil coupled with improved soil characteristics, essentially leads to higher crop yield in many cropping and climatic situations. The crop residues act as a reservoir for plant nutrient; prevent leaching of nutrient, increases crop production.

High cost of collection and lack of economically viable options to utilize this valuable bio-resource are identified as factors, compelling the farmers to burn it. The most preferable solution to address this problem by the state is to diversify cropping pattern and reduction of area under rice cultivation. However, it can be possible only when state is able to provide other alternative economically viable options to the farmers. Preference of growing of crop mainly depends on economic return, availability of inputs, type of soil and food habit of the farmers, therefore, diversification of cropping pattern to reduce the area under rice may not be feasible and acceptable to the farmers. To address the issue of crop residue burning, this study will facilitate in creating awareness about ill effects of crop residue burning, alternatives multiple uses of crop residue, financial support available under various ongoing schemes/programmes of Government of India and State Government for this purpose.

The crop residues act as reservoir for plant nutrients, prevent leaching of nutrients, increase Cation Exchange Capacity (CEC), provide congenial environment for biological N2 fixation, increase microbial biomass and enhance activities of enzymes such as dehydrogenised and alkaline phosphatase. Increased microbial biomass can enhance nutrients availability in soil as well as act as sink and source of plant nutrients and leaving substantial amounts of crop residues evenly distributed over the soil surfaces increases infiltration, moisture retention and reduces runoff.

The crop residues play an important role in amelioration of soil acidity through the release of hydroxyls especially during the decomposition of residues with higher C:N ratios, and soil alkalinity through application of residues from lower C:N ratio crops including legumes: oilseeds and pulses. The role of crop residues on carbon sequestration in the soil would be an added advantage for climate change adaptation and mitigate adverse impact too. Yield response with residue management varies with soil characteristics, climate, cropping patterns, and level of management skills. Higher yields with crop residue application results from increased infiltration and improved soil properties, increased soil organic matter and earthworm activity and improved soil structure after a period of 4-7 years.

As per the Seventh Schedule of the Constitution of India, subject of agriculture falls under the purview of the State Governments, therefore, it is for the State Governments to take necessary steps for curbing the practice of crop residue burning. Government of India's role on such matters are limited to advisory to the State Governments and accordingly, various meetings are being organized at regular intervals mainly to sensitized State Governments for taking measures to address the problems of crop residue burning which is resulting in loss of soil fertility, agricultural production and productivity; apart from causing air pollution. Accordingly States namely; Andhra Pradesh, Bihar, Gujarat, Haryana, Punjab, Karnataka, Madhya Pradesh, Maharashtra and Uttar Pradesh have taken legislative measures to curb crop residue burning.

Management of crop residue sustaining soil fertility and foodgrains

Studies have recommended alternatives as per details given below for prevention of crop residue burning and also environmental and soil degradation:

Collection and Storage: For the proposed industrial and on-farm uses of rice straw, its collection, chopping and baling are issues which need to be addressed from the economic angle (due to shortage of farm labour). Further, storage of such large quantities of rice straw without degradation due to bacterial/fungal attacks (and/or fire) also needs to be taken care of. Some biomass based power plants are promoting storage under vacuum conditions in temporary silos using large inflatable bags. There is thus a need to encourage collection and storage of paddy straw in catchment areas of relevant industries.

Cost Effective Mechanization: Agriculture in North Western parts of India is highly mechanized and the concept of hiring large and costly farm equipment (like combine harvesters) is well established. The State Agriculture Department has initiate setting up of Agriculture Service Centers in the cooperative sector for providing machinery like Happy Seeders, rotavators etc. on rent. The numbers of such centres need to be increased with regard to land holdings in an area. There is need to provide subsidies on other technologies/machinery related to paddy straw management such as Paddy straw chopper-cum-spreader, S traw bailer, etc.

Promotion of R&D, Technology Dissemination: The Departments of Agronomy and Crop Science, Farm Machinery, Soil Sciences, School of Energy Studies, Biotechnology and Extension Education of Punjab Agricultural Universities have to play a major role in Paddy straw management through need based R&D. PAU has successfully developed Happy Seeder machines which facilitate sowing of wheat in standing paddy stubble, while retaining the straw as surface mulch and being promoted under various schemes. Further, PAU has developed tractor operated straw chopping-cum-spreading machine, which can chop and spread combine harvested rice in a single operation. The chopped and spread straw can easily buried in soil by using rotavators. Subsequently, wheat sowing can be carried out by using strip-till drill or no-till drill after 2-3 weeks. Thus, the presence of straw in the field does not affect the sowing of the next crop. Rather, it allows incorporation of nitrogen and other minerals into the soil, thus improves soil properties. Promoting straw balers which can recover about 200-250 bales of 15 to 30 kg weight from combine harvested fields. The bales can be easily transported for use in power generation, briquette formation, other industrial uses and composting.

Genomic Studies: In order to promote research in Biotechnology, the National Agri-Biotechnology Institute has been set up as a joint Endeavour of the Government of India and Government of Punjab. There is a need to develop cultivars with low silica content without compromising its quality to resist lodging, availing benefit of this joint endeavor.

Mobilization of finance to curb crop residue burning: Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare is not having specific scheme/ programme to curb crop residue burning, however, the interventions for management of crop residues are being supported under ongoing programmes/schemes. State need to identify need based, location specific interventions suitable to particular agro-ecological zones and can proposed for financial assistance from Parampragat Krishi Vikas Yojana (PKVY), which provides flexibility to the states for taking up any components required for development of agricultural production across the country. Financial resources can be also mobilized by convergence with other ongoing programmes/Missions, namely; National Food Security Management, National Horticulture Management, National Missionary for Oilseed and Oil Palm, National Mission on Agriculture Extension Technology and National Mission for Sustainable Agriculture, besides taping of resources of other Ministries with objective specific interventions.

Summary and Way forward:

Management of crop residue for sustaining soil fertility and foodgrains production seeks following interventions;

- **a.** Adoption of crop rotation as recommended in the Soil Health Care provided by Ministry of Agriculture and Farmers Welfare or ICAR and growing of short duration, dwarf varieties of Rice/Wheat crops which may lead to less crop residue production and higher period between harvesting and sowing of next crop;
- **b.** Massive capacity building and training of farmers, about benefits of incorporation of crop residue into the soil and providing improved machines available for this purpose preferably by Custom Hiring System (CHS) Agriculture Service Centre;
- **c.** Promotion of happy seeder machines which facilitate sowing of wheat in the standing rice stubble, while retaining the straw as surface mulch and Zero-till Seed drill etc.
- **d.** Promotion of conservation agriculture technologies/machines and ensuring its availability to the farmers at nominal cost from CHS and offering subsidy under different ongoing programmes, as individual farmers cannot afford to have such costly machines, and incentivize incorporation rice straw in the soil by use of Happy Seeders and Rotavators or disc harrows;
- **e.** Promote utilization of crop residue through community mobilization as animal hay bedding, fodder, composting and mushroom cultivation;
- **f.** Proposal for purchase of equipment's for establishment of CHS/ASC, including interventions for multiple use of crop residue, establishment of bio-power plant, etc. for the areas prone for crop residue burning can be funded from various on-going programmes/schemes viz. Parmparagat Krishi Vikas Yojana (PKVY), National Food Security Mission (NFSM), National Mission for Sustainable Agriculture (NMSA) etc of DAC and FW;

g. Use of rice straw as fuel for biomass power plants and establishment of such plants in Public Private Partnership (PPP) model;

h. Promotion and encouragement of use of crop residue/rice straw in paper/board/panel and packing;

i. Promotion of biotechnological approaches to reduce silica and enhance decomposition of crop residue/rice straw so that the biomass can be utilized as fuel as well as for other industrial applications; and

j. Promotion of collection of crop residue for feed, brick making etc. and extending support for transporting of such residue to fodder deficient areas;

k. Development of cost effective farm machinery to facilitate collection, volume reduction, transportation and application of residues;

l. Modifying combine harvester to collect finely chopped crop residues by use of twin cutter bar type combine harvester for harvesting of top portion of crop for grain recovery and a lower cutter bar for straw harvesting at a suitable height and windrowing should be developed for proper management of straw;

m. Use of satellite based remote sensing technologies to monitor crop residue management with active collaboration of NRSA;

n. As per Seventh Schedule of the Constitution of India, subject of agriculture falls under the purview of the State Governments, therefore, it is for the State Governments are mainly responsible for taking necessary steps to curb the practice of crop residue burning;

o. Incentivizing and encouragement to farmers for establishment of projects aiming at utilization of crop residues as raw materials by entitling them to all benefits as permissible under the Fiscal Incentives for Industrial Promotion schemes/ programmes in the respective State;

p. Ministry of Environment and Forests and Climate Change (MoEF and CC) has two Acts namely; "The Air (Prevention and Control Pollution) Act 1981" and "The Environment (Protection) Act 1986" which has provision for incentivizing to farmers, not to resolve crop residue burning needs to be suitably included as a sub-section along with penal actions against farmers for violation of provisions. Promotion of monitoring of such incidences by using remote sensing technologies with active involvement of NSRA, so that provisions are enforced and a complete ban on crop residue burning is ensure;

q. Organizing training of farmers for creating awareness about effects of crop residue burning, adoption of conservation agriculture practices and resource conservation technology through all ongoing State/Centre Sector Schemes;

r. Creation of awareness about various measures to prevent crop residue burning through mass media, print media, etc. just before harvesting seasons;

s. Establishing self-help groups and providing subsidy to unemployed youth for establishment of custom hiring centres to enhance the availability of resource conservation machinery; and

t. Demonstrations of crop residue management technology on a large scale by State Agriculture and other Government Institutions by organizing to create awareness and dissemination of various technologies under ongoing schemes.

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