

REPORT OF THE COMMITTEE

ON

**REVIEW OF THE SCHEME "PROMOTION OF AGRICULTURAL
MECHANISATION FOR IN-SITU MANAGEMENT OF CROP RESIDUE IN
STATES OF PUNJAB, HARYANA, UTTAR PRADESH AND NCT OF DELHI"**



सत्यमेव जयते

GOVERNMENT OF INDIA


MINISTRY OF AGRICULTURE AND FARMERS WELFARE

(DEPTT. OF AGRICULTURE, COOPERATION & FARMERS WELFARE)


KRISHI BHAWAN, NEW DELHI

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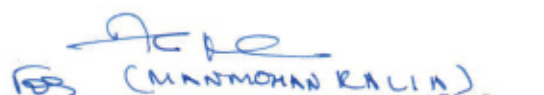
The Committee constituted to look into the issues of crop residue burning vide order dated 19.11.2018, present its report to the Government of India, Ministry of Agriculture and Farmers Welfare (Department of Agriculture, Cooperation & Farmers Welfare)




Dr. Nagesh Singh
Chairman




(Nominee for)
ADG (Engg.)
DDG (Engg)-ICAR
Member



(MANMOHAN KALIN)
Additional Chief Secretary
(Agriculture)
Government of Punjab
Member



(Nominee for)
ADG
Additional Chief Secretary
(Agriculture)
Government of Haryana
Member



AE (Hr.)
Principal Secretary
(Agriculture)
Government of Uttar
Pradesh
Member



Joint Secretary (M&T)
DAC&FW
Convener

CONTENTS

Chapter Number	Subject	Page No.
I	Introduction	1
II	Assessment of the Problems.	4
III	Measures by the Government of India to reduce Crop Residue Burning.	8
IV	Assessment of the Scheme	16
V	Assessment and impact of the machinery use by the farmers & Assessment of the benefits accrued to the farmers.	30
VI	Paddy Varieties for Promoting Better Straw Management	36
VII	Crop Diversification	42
VIII	Observations from the Field	47
IX	Use of crop Residue	52
X	Summary & Recommendations	56
	Annexure - I to Annexure - XVI	59 to 84

REPORT ON CROP RESIDUE MANAGEMENT

CHAPTER I

INTRODUCTION

- 1.1 Paddy straw burning is practiced in Punjab, Haryana & Uttar Pradesh to clear the fields for Rabi Crop sowing during October/November i.e mainly wheat and potato, because the time window available between the harvesting of paddy crop and the sowing of next crop is very short (2-3 weeks). Use of paddy straw as fodder is limited due to high silica content.
- 1.2 The poor air quality in the NCR region, especially during winter months and the impact of crop residue burning (Paddy Straw) during October-November period every year has been a matter of grave concern. It is estimated that about 80% of Delhi's pollution is due to vehicular emission, construction, industrial pollution, dust etc. within the national capital's limits. However, stubble (paddy straw) burning is an episodic (seasonal) problem which contributes to the surge in pollution in Delhi during the Paddy Harvesting season i.e. November-December. Its contribution to poor air quality of Delhi is estimated between 25% to 30% on the days when stubble burning peaks in Punjab and Haryana. It severely affects the air quality in Punjab and Haryana and also damages soil health which impacts agricultural productivity.
- 1.3 The State Governments and the Government of India have taken a number of steps in the past to persuade farmers to stop burning crop residue. Notifications banning burning of crop residue, subsidy to farmers to acquire farm machinery that could promote in-situ crop residue management, use of paddy straw in power plants and other industries have also been taken on hand. However, in view of the limited impact of these measures, the Government of India in the year 2018 decided to launch a Central Sector Scheme on "Promotion of Agricultural Mechanization for in-situ management of crop residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi". The scheme was rolled out in April 2018. The scheme provided for higher level of subsidy to farmers for purchasing a bouquet of machineries for in-situ crop residue management. Subsidy of 50% of the cost of machines to individual farmers and 80% for Cooperative Societies, Farmers' Interest Groups and other collectives of farmers was provided to reduce their financial burden. The scheme also provided assured market for these machineries so that machinery manufacturers could ramp up their production facilities. Stringent quality control norms were

prescribed for these machines and monitored by different institutions of the State Governments, Universities and Central Govt. Institutions. States were provided funding to take up IEC activities, including field demonstrations. The entire funding for the scheme was provided by the Govt. of India.

1.4 National Green Tribunal (NGT), Principal Bench, New Delhi took cognizance of some of the newspaper reports in original application No.666/2018 of Smt. Ganga Lalwani V/s. Union of India and Ors. which indicated that crop residue burning was still rampant in Punjab and Haryana and directed Chief Secretaries of States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi to communicate to the court strategic plan and action to prevent crop residue burning. The NGT in its order on 15.11.2018 directed the Ministry of Agriculture & Farmers Welfare, Government of India to continue to monitor the steps in continuation of its meeting held on 14.11.2018 and furnish a status report to the Tribunal on or before 30.04.2019.

1.5 The Government of India, Ministry of Agriculture and Farmers Welfare vide order dated 19.11.2018 constituted a committee to look in to the issue of crop residue burning and make an assessment of the implementation and impact of the Central Sector Scheme initiated in the year 2018 for crop residue management. The Committee was headed by Dr. Nagesh Singh, former,

Addl. Secretary, Ministry of Rural Development and currently Head, Centre for Poverty Studies and Social Registry, NIRD&PR, Ministry of Rural Development, Govt. of India. The other members of the committee were, Additional Chief Secretary/ Principal Secretary (Agriculture) of Government of Punjab, Haryana and Uttar Pradesh, Deputy Director General (Engg.), ICAR, and Joint Secretary(M&T), DAC&FW as the Convener. Office order regarding the constitution of committee is at **Annexure-I**. The Terms of Reference (ToRs) of the committee were as under:

- (i) Assessment of the numbers of machinery distributed in States of Punjab, Haryana and Uttar Pradesh under the Central Sector Scheme of in-situ crop residue management .
- (ii) Assessment and impact of the machinery use by the farmers.
- (iii) Assessment of the benefits accrued to the farmers.
- (iv) Recommending the area specific varieties of paddy crops for the areas where crop burning is higher .
- (v) Suggesting alternative more remunerative and advantageous industrial use of crop residue in respective States.
- (vi) Recommending other inputs, for making long term policy for preventing crop residue burning.

- 1.6 The first meeting of the committee was held on 13.12.2018 at Chandigarh. The minutes of the meeting are at **Annexure-II**. Thereafter, the Committee members /representatives of the members of the committee visited Ludhiana, Sangrur and Patiala districts of Punjab and Karnal, Kurukshetra & Panipat districts in Haryana during 13-15 December 2018. During this visit the committee discussed the issues with various farmer groups and also interacted with machinery manufacturers in Punjab and Haryana and reviewed their preparedness to supply these machines on time to farmers in the 2019-20 seasons. The after sales service provided by the manufacturers to the farmers was also noted. The list of villages and factories visited by the committee are at **Annexure-III**.
- 1.7 The Committee met scientists from ICAR, faculty members of the Punjab Agricultural University, Ludhiana and other officials from governments of Punjab and Haryana on 30th January, 2019 to elicit their views on issues of crop diversification, and promotion of paddy varieties of which massive convey and have lower straw production. The minutes of the meeting are at **Annexure-IV**.
- 1.8 The committee again visited Punjab, Haryana on 22-23rd March and held extensive discussions with farmers in Hisar, Sirsa and Fatehabad districts in Haryana and Bathinda, Sangrur and Ludhiana districts in Punjab. The committee also interacted with Sarpanches, Cooperative Society members and a few Farmer Producer Organizations (FPOs). The list of villages visited by the Committee is at **Annexure-V**.
- 1.9 The report of the committee is based on information gathered by the committee members during their visits to Punjab and Haryana and materials supplied by the State governments. We are constrained to point out that there was no participation from Uttar Pradesh in the Committee Meetings. The report is, therefore, mostly confined to the situation in the Punjab and Haryana only.

CHAPTER - II

ASSESSMENT OF PROBLEMS

- 2.1 Paddy straw burning is currently practiced on a large scale in Punjab & Haryana to clear the fields for Rabi Crop sowing i.e mainly wheat and potato, because the time window available between the harvesting of paddy crop (20th September to 15th November, depending upon the varieties of paddy) and the sowing of next crop is very short (2-3 weeks). Large scale burning takes place in areas where farmers grow vegetables just after the harvesting of paddy.
- 2.2 Burning of paddy straw is most common in combine harvested fields because it leaves harvested paddy straw and standing stubbles (25-30 cm height) in the field.
- 2.3 Environmentally sustainable paddy crop residue management practices along with traditional methods for sowing of wheat and other costs entail incremental costs for the farmers (additional tractor operations and use of required machinery etc.). Farmers prefer burning of stubble to avoid incurring such costs.
- 2.4 **Adverse effect of crop residue burning:**
- 2.4.1 **Loss of nutrients:** It is estimated that burning of one tonne of paddy straw accounts for loss of 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% of Nitrogen (N), 25% of Phosphorus (P), 50% of Sulphur (S) and 20% of Potassium(K). If the crop residue is incorporated or retained in the soil itself, it gets enriched, particularly with organic C and N.
- 2.4.2 **Impact on soil properties:** Heat from burning residues elevates soil temperature causing death of beneficial soil organisms. Frequent residue burning leads to loss of microbial population and reduces level of N and C in the top 0-15 cm soil profile, which is important for crop root development.
- 2.4.3 **Emission of green house and other gases:** Crop residues burning is a potential source of Green House Gases (GHGs) and other chemically and radioactive important trace gases and aerosols such as CH₄, CO, N₂O, NO_x and other hydrocarbons. It is estimated that upon burning, Carbon (C) present in rice straw is emitted as CO₂(70% of Carbon present), CO (7%) and CH₄(0.66%) while 2.09% of Nitrogen (N) in straw is emitted as N₂O. Besides, burning of crop residue also emits large amount of particulates that are composed of wide variety of organic and inorganic species. 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.

2.5 Context of Haryana:

2.5.1 The area under Paddy Cultivation during the year 2018-19 in the State of Haryana is 14.45 Lakh Hectare (as reported) out of which 7.95 Lakh Hectare is devoted to Basmati Paddy Variety and 6.49 Lakh Hectare to Non-Basmati Paddy Variety. The total quantity of paddy straw generated during the year 2018-19 is estimated at 79.31 Lakh MT. It is a practice among the farmers to burn the paddy straw after harvest, which begins around 20th September & last till 20th November.

2.5.2 Basmati Paddy is largely harvested using manual labour which results in significantly lower amount of crop residue in the field and hence less burning. The straw of the basmati is also used as animal fodder in Haryana. However, 7% to 10% of Basmati Paddy area is also reported to be affected by incidence of crop residue burning.

2.5.3 In districts like Sirsa and Fatehabad due to large land holdings and shortage of labour, Combine harvester is used for harvesting Basmati also. As a result, large number of incidents of basmati paddy straw burning was reported in these districts. The non-basmati paddy straw is subjected to large scale burning because it is not used for consumption of animals.

Table -1 below provides information on paddy straw that needs to be managed in the State of Haryana

Table -1

S.No.	Parameters	Data
1	No of affected districts of crop residue burning	22 Districts
2	Area under Paddy under these affected districts (ha)	14.47 lakh ha (Basmati 7.95 lakh ha and Non-Basmati 6.49 lakh ha)
3	Area being already managed.	7.14 lakh ha
4	Target Area.	7.3 lakh ha (100% Non-Basmati 6.51 Lakh ha + 10% Basmati 0.79 Lakh ha)
5	Crop residue generated in these districts.	7.93 Million Metric Tons
6	Crop residue utilized*	6.59 Million Metric Tons
7	Crop residue burnt.	1.34 Million Metric Tons

*4.76MT managed through all other usage including incorporation, 1.83 MT left on road side or partially burnt

2.5.4 As indicated above Basmati occupies more than 50% of paddy acreage in Haryana. Since Basmati is harvested manually, which does not leave paddy straw residue on the field, the problem of burning is confined basically to the non-basmati acreage. The district-wise detail of Basmati and non-Basmati acreage and paddy straw that needs to be managed for Haryana is given in Annexure VI. The districts which generate large volume of paddy straw are Karnal, Kaithal, Kurukshetra, Fatehabad, Ambala and Yamunanagar. In the Mewat region, cultivation of paddy is negligible.

2.6 Context of Punjab:

2.6.1 The area under Paddy Cultivation during the year 2018-19 in the State of Punjab is 31.03 Lakh Hectare (as reported) out of which 5.11 Lakh Hectare is devoted to Basmati Paddy Variety and 25.92 Lakh Hectare to Non-Basmati Paddy Variety. The total quantity of paddy straw generated during the year 2018-19 is 201.70 Lakh MT.

2.6.2 Details of area under Basmati and non-Basmati paddy and paddy straw burning in the year 2018 is indicated in Annexure VII. Paddy straw burning is prevalent in all districts. Sangrur, Muktsar, Ludhiana, Firozpur and Bhatinda accounted for large volume of paddy straw burning in the state. Table -2 below provides information on paddy straw that needs to be managed in the State of Punjab

Table - 2

S.No.	Parameters	Data
1	No of affected districts of crop residue burning	22 Districts
2	Area under Paddy under these affected districts (Ha)	31.03 lakh ha (Basmati 5.11 lakh ha and Non-Basmati 25.92 lakh ha)
3	Area being already managed.	6.61 lakh ha
4	Target Area.	19.31 lakh ha
5	Crop residue generated in these districts.	20.17 Million Metric Tons
6	Crop residue Managed*.	10.21 Million Metric Tons
7	Crop residue burnt.	9.96 Million Metric Tons

*7.32MT managed through all other usage including incorporation, 2.89 MT left on road side or partially burnt.

2.7 The above analysis indicates that total paddy straw produced in Haryana and Punjab together is 28.10 million tonnes (2018 estimates) out of which 11.3 million tonnes was burnt in the fields. 59.79% of the straw was managed through incorporation in the soil and other measures. In Haryana 16.9% of the straw was burnt while in Punjab it was 49.47%. Haryana accounted for 11.85% of the straw while Punjab accounts for 88.15% of the straw burnt in these two States. Large scale burning is confined to Fatehabad, Sirsa, Kaithal, Karnal

and Kurukshetra in Haryana. In Punjab, Sangrur, Bhatinda, Firozpur, Muktsar, Mansa and Patiala witnessed high incidence of burning. However, in districts like Patiala, there was significant reduction in burning in 2018 compared to previous years. These districts would require focused attention with greater emphasis on IEC activities to promote CRM machinery. Some form of coercive action, such as imposition of fines on farmers still indulging in burning of paddy straw would also be helpful in combating straw burning.

CHAPTER - III

MEASURES BY THE GOVERNMENT OF INDIA TO REDUCE CROP RESIDUE BURNING

- 3.1 In pursuance to Budget 2018 announcement regarding 'a special Scheme to support the efforts of the governments of Haryana, Punjab, Uttar Pradesh and the NCT of Delhi to address air pollution and to subsidize machinery required for in-situ management of crop residue', a new Central Sector Scheme on 'Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi' for the period from 2018-19 to 2019-20 was proposed.
- 3.2 The Cabinet Committee on Economic Affairs (CCEA) considered the proposal on 7th March 2018 and approved the scheme with the total outgo from the Central funds of Rs. 1151.80 crore (Rs. 591.65 crore in 2018-19 and Rs. 560.15 crore in 2019-20). The scheme has the following objectives:
- (i) Protecting environment from air pollution and preventing loss of nutrients and soil micro-organisms caused by burning of crop residue;
 - (ii) Promoting in-situ management of crop residue by retention and incorporation into the soil through the use of appropriate mechanization inputs;
 - (iii) Promoting Farm Machinery Banks for custom hiring of in-situ crop residue management machinery to offset the adverse economies of scale arising due to small landholding and high cost of individual ownership.
 - (iv) Creating awareness among stakeholders through demonstration, capacity building activities and differentiated Information, Education and Communication strategies for effective utilization and management of crop residue.
- 3.3 The Scheme has the following components (100% Central Share)
- (i) Establish Farm Machinery Banks for Custom Hiring of in-situ crop residue management machinery -financial assistance @ 80% of the project cost is provided to the Co-operative Societies of farmers, FPOs, Self-Help Groups, registered Farmers Societies / farmers groups, Private Entrepreneurs, Group of women farmers or self-help groups for establishment of farm machinery banks or custom hiring centres of in-situ crop residue management machinery. Groups of farmers / individual farmers having their own tractor / combine harvester would be preferred for establishing Custom Hiring

Centre (CHC). Old established CHCs, with Non-Crop Residue Machinery, will also be eligible for a fresh project under the scheme.

- (ii) Financial Assistance to farmers for Procurement of Agriculture Machinery and Equipment for in-situ crop residue management - financial assistance @ 50% of the cost of machinery/equipment is provided to individual farmers or purchase of machinery /equipment for crop residue management.
- (iii) Information, Education and Communication for awareness on in-situ crop residue management - financial assistance is provided to the State Governments, KVKs, ICAR Institutions, Central Government Institutions, PSUs etc. for the activities to be undertaken towards information Education and Communication (IEC). The activities will involve mass awareness campaigns through short and long films, documentaries, radio and TV programmes, demonstration camps at various levels, capacity-building programmes, advertisements in print media, star campaigning, award for village/ gram Panchayat for achieving zero straw burning, panel discussions on Doordarshan, DD Kisan and other private channels, etc.

3.4

Approval of Annual Action Plan and Fund Flow Mechanism of the Scheme

- (i) Annual Action Plan (AAP) duly approved by State Level Executive Committee (SLEC) under the Chairmanship of Principal Secretary (Agriculture)/Agriculture Production Commissioner (APC) along with the minutes of SLEC or AAP duly approved by ICAR in case of ICAR institutions and KVKs, is submitted to Department of Agriculture Cooperation and Farmers Welfare (DAC&FW) for examination, deliberation and final approval.
- (ii) Mechanization & Technology (M&T) Division of DAC&FW examines the AAP before it is placed before the Executive Committee (EC) under the chairmanship of Additional Secretary for consideration, sanction and approving allocation of funds to States and implementing agencies.
- (iii) DAC & FW allocate the funds to the States and Implementing Agencies based on the duly approved annual action plan by the SLEC and EC. As this is Central Sector Scheme having no share of State Government, the funds are released directly into the account of the implementing agencies through PFMS as per the guidelines of Ministry of Finance and the treasury route is not followed.

(iv) The District Level Executive Committee (SLEC) under the Chairmanship of Collector /Deputy Commissioner is responsible for carrying forward the objectives of the scheme for project formulation, implementation and monitoring.

(v) SLEC Identify beneficiaries (Farmers, Co-operative Societies of farmers, FPOs, Self-Help Groups, registered Farmers Societies / farmers groups, Private Entrepreneurs, Group of women farmers or self-help groups) to avail the benefits of scheme in transparent and time bound manner.

(vi) The buyer (farmer) is free to purchase the equipment /machine from any of the empanelled Manufacturer on payment of full cost of the equipment/machine or he will pay the amount after deducting the amount of applicable subsidy. In case of full payment by the buyer (farmer) to the Manufacturer, the amount of applicable subsidy is paid to the buyer directly in his account.

(vii) In case the buyer (farmer) pay cost of machine/equipment after deducting the amount of applicable subsidy, the amount of subsidy is paid to the Manufacturer in his account within one month of supply, installation and commissioning of the machine/equipment. The

buyer will give certificate of complete Installation and successful commissioning which is also physically verified by the District level Agriculture Officer.

(viii)The distribution of subsidy is done by the district level committee.

3.5 Equipments and Machines Identified for Promotion under the Scheme .

The Sub-Committee of Task Force under the chairmanship of Secretary (Department of Agriculture Research & Education) and Director General (Indian Council of Agricultural Research) in their concept note for the scheme identified the following machines and equipments for in-situ crop residue management.



Super Straw Management System



Happy Seeder



Hydraulic Reversible M.B. Plough



Rotary Mulcher



Shrub Master



Paddy Straw Chopper/Shredder



Rotavator



Zero Till Seed Cum
Fertilizer Drill

3.6 Empanelment of Manufacturers for Supply of Machines:

- (i) The Request for Proposal (RFP) document for inviting Expression of Interest (EOI) for empanelment of manufacturers for supply of machines and equipments under the Central Sector Scheme 'Promotion of Agricultural Mechanization for In-situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi' was uploaded on the Central Procurement Portal on 23.03.2018 for inviting online proposals from the manufacturers.
- (ii) For wider publicity of the EOI, an advertisement was published in all the leading newspapers (All India Editions) in English and Hindi Language on dated 24th March 2018 and repeated on 17th April 2018. The email and Whatsapp messages were also sent to the manufacturing associations for circulation among their members.
- (iii) The online bid submission end date was 19.04.2018. The technical bids received online (88 Nos.) were opened by the

committee on 20.04.2018 and financial bids opened on 26.04.2018. The price negotiations with the qualified manufacturers was conducted by the Empanelment Committee on 27.04.2018 & 01.05.2018

- (iv) The list of 82 manufacturers who had qualified for empanelment and submitted the Performance and Bank Guarantee was finalized and sent to the State Governments on 4th June 2018.
- (v) Subsequent to the finalization of the list of 82 manufacturers, the Government of Punjab vide letter dated 4th June 2018 informed that the matter has been discussed at the level of Chief Secretary that it is not possible for limited number of suppliers to fulfill the huge demand of equipment in a limited period of 3 months. Many manufacturers and Associations of manufacturers who could not apply for the empanelment have approached their department for additional opportunity for empanelment in the scheme. They have also informed that a decision has been taken on 29.05.2018 in the meeting of all stakeholders with Chief Secretary of Punjab, to call for additional invitation of manufacturers in the scheme for allowing broader participation of manufacturers.

- (vi) Looking into the above, the offline proposals from the additional manufacturers were invited by 22.06.2018. Subsequently, after the price negotiation with the manufacturers an additional list of 202 manufacturers was sent to the State Governments on 29.07.2018.
- (vii) Some of the important criteria for empanelment of manufacturers was as under:
- Valid Industry Registration
 - PAN No & GSTIN Registration
 - Valid report of testing of the machines
 - Machines should be as per Standard specification only.
 - Higher quality of soil engaging components (e.g. Boron Steel, High Carbon Steel)
 - Performance Guarantee
 - 15 months warranty on the machines
 - All the machines should bear engraved unique serial number on the main frame of the machine
 - Manufacturers should provide adequate training to the buyer on operation and maintenance of the machines
 - All equipments/machines should be brand new and manufactured during the current year
- (viii) The equipment-wise and State-wise numbers of manufacturers empanelled for supply of equipments is given in Table -3

Table -3

Name of the Machine	State-wise number of manufacturers							Total No. of empanelled manufacturers (Nos.)
	PB	HR	UP	GJ	TN	MH	MP	
SSMS	79	2	1	0	0	1	0	83
Happy Seeder	16	6	0	0	0	0	2	24
Straw Chopper	24	3	0	1	0	0	1	29
Shrub Master	1	0	0	0	0	0	0	1
MB Plough	3	2	0	5	1	2	2	15
Rotary Slasher	0	0	0	0	0	0	01	1
Zero Till Drill	61	38	2	1	0	1	1	104
Rotavator	111	40	2	4	2	4	3	166

3.7 Benchmark Cost & the applicable subsidy on the machines under the scheme is given in Table -4

Table - 4

S.No.	Name of the machine/equipment	Maximum price for the purpose of subsidy including GST @12% (Rs.)	Maximum Permissible subsidy per Machine/ Equipment per beneficiary (Rs.)
1	2	3	4
1.	Super Straw Management System (Super SMS) to be attached with Combine Harvester	1,12,000	56000
	Happy Seeder		
	a) 09 tine	1,45,600	72,800
	b) 10 tine	1,51,200	75,600
	c) 11 tine	1,56,800	78,400
3.	Paddy Straw Chopper/ Shredder/Mulcher		
	a) Mounted type (Straw Chopper & Mulcher)		
	i) 5 ft	1,34,400	67,200
	ii) 6 ft	1,45,600	72,800
	iii) 7 ft	1,56,800	78,400
	iv) 8 ft	1,68,000	84,000
	b) Trailed type	2,52,000	1,26,000
	Combo type	2,80,000	1,40,000
4.	Shrub master / cutter cum spreader	44,800	22400
5.	Hydraulic Reversible M.B. Plough		
	a) Two bottom	1,40,000	70,000
	b) Three bottom	1,79,000	89,500
6.	Rotary Slasher	44,800	22400
7.	Zero Till drill		
	9 tine	42,560	21,280
	11 tine	48,160	24,080
	13 tine	53,760	26,880
	15 tine	56,000	28,000
8.	Rotavator		
	5 feet	84,000	42,000
	6 feet	89,600	44,800
	7 feet	95,200	47,600
	8 feet	1,00,800	50,400

(If the price of equipment is more than the price of equipment indicated in Column 3, then the subsidy will be limited as indicated in Column 4. If the price is lower than the price indicated in column 3, then the subsidy will be limited to 50% of the actual cost)

3.8

Funds Released to the States and Implementing Agencies During 2018-19

The funds have been released to the States and implementing agencies in the month of **May 2018** is given in Table -5

(Rs. in Crores) Table-5

States/ Agency	Funds released for				Total funds released
	Establishment of CHCs	Distribution of machinery	IEC activities	Flexi Funds/ Admn. Expenses	
Punjab	176.00	71.30	16.80	5.28	269.38
Haryana	72.00	41.50	21.64	2.70	137.84
Uttar Pradesh	37.58	95.27	12.84	2.91	148.6
ICAR & Other Central Agencies	0	0	26.58	1.93	28.51
Total	285.58	208.07	77.86	12.82	584.33

3.9 Physical Targets & Achievement (2018-19): The target date for distribution of machinery and equipments to the individual farmers and Custom Hiring Centres was initially fixed as 31.07.2018. However, based on the request of the

States, the last date was extended to 15.11.2018. Based on the reports submitted by the States and implementing agencies the physical achievement of distribution of machinery and establishment of CHCs by 15.11.2018 is as under:

Table-6

State / Agency	No. of Machines to individual farmers			No. of CHCs		
	Target	Ach.	% Ach.	Target	Achievement	% Ach.
Punjab	8309	12082	145%	5288	4466	85%
Haryana	3582	3554	99%	900	1194	133%
UP	19164	16406	86%	1015	2300	227%
ICAR	560	528	94%	--	--	--
TOTAL	31615	32570		7203	7960	

3.10. The Government of India and the State governments of Punjab and Haryana rolled out the programme in the right earnest in 2018 to position CRM machineries in the field before harvesting of paddy so that it was available to farmers for sowing of wheat. The physical target for providing machinery in 2018-19 for individual farmers was over achieved in Punjab and was 99% in case of Haryana. A major issue however, was the delayed supply of machinery to farmers, especially in Punjab where the final date for supply of machinery was extended to 15.11.2018, a date by which time wheat sowing was almost completed. The Committee was not able to get data on supply of machinery to farmers date-wise in each districts. From our interactions with the farmers, it clearly emerged that had machineries been provided by end of September/beginning October, sowing through Happy Seeder would have been on a bigger scale.

As 2018 was the first year of the roll out of the schemes, such delays could be expected. The Committee strongly recommends that CRM machineries to be provided in 2019-20 should be positioned in the field by 30th September. The machinery manufacturers have already ramped up their production capabilities and firm order from the State governments well in time would ensure that machinery is in place by 30th September, 2019. This is also important to ensure that each CRM machinery is utilized to its full potential, reducing the need for over-capitalisation in the sector. The Committee also noted with concern that deployment of CRM machinery in Uttar Pradesh was extremely lop-sided. In Uttar Pradesh largely rotavators and some zero till drills were distributed. The major expenditure was on rotavator only. The rotavator is useful for sowing of potato and is not really relevant for sowing of wheat.

CHAPTER - IV

ASSESSMENT OF THE SCHEME

- 4.1 **Assessment of the numbers of machinery distributed in States of Punjab, Haryana and Uttar Pradesh:**
- 4.1.1 During 2018, the target date for distribution of machines to the individual farmers and the Custom Hiring centres was 15.11.2018.
- 4.1.2 All the three State Governments i.e. Punjab, Haryana and Uttar Pradesh have distributed 32570 different machines to the farmers on individual ownership basis and established 7960 Custom Hiring Centres.
- 4.1.3 The State of Punjab have distributed 12082 machines to the farmers on individual ownership basis and have established 3950 Custom Hiring Centres which includes Cooperative Societies and Farmers Groups. Total 28609 machines have been distributed in the State during 2018-19. The District-wise numbers of various machines distributed to the Individual farmers and Custom Hiring Centres in the State of Punjab is given in **Annexure-VIII**
- 4.1.4 The State of Haryana have distributed 3554 machines to the farmers on individual ownership basis and have established 1194 Custom Hiring Centres which includes Cooperative Societies, Farmers Groups and Entrepreneurs. Total 10747 machines have been distributed in the State during 2018-19. The District-wise numbers of various machines distributed to the Individual farmers and Custom Hiring Centres in the State of Haryana is given in **Annexure-IX**.
- 4.1.5 The State of Uttar Pradesh have distributed 16406 machines to the farmers on individual ownership basis and have established 2300 Custom Hiring Centres which includes Farmers Groups and Entrepreneurs. The District-wise numbers of various machines distributed to the Individual farmers and the district-wise Custom Hiring Centres established in Uttar Pradesh is given in **Annexure-X**.
- 4.1.6. The State-wise different types of equipments distributed (including individual farmers and Custom Hiring Centres) are given in Table-7

Table-7

Name of the Machine/ Equipment	Number of Machines			
	Punjab	Haryana	*UP	Total
SMS	3634	909	8	4552
Happy Seeder	9758	2376	24	12158
Reversible M.B. Plough	3034	1159	232	4425
Shrub Master / Cutter Cum Spreader	86	216	14	316
Straw Chopper / Shredder / Mulcher	4486	1581	96	6163
Rotary Slasher	484	265	11	760
Zero Till Drill	3437	2527	906	6870
Rotavator	3690	1714	15115	20519
TOTAL	28609	10747	16406	55762

*The data of UP relates to machinery supply to individual farmers only.

4.2 Assessment of the Information, Education and Communication (IEC) Activities Conducted in the States:

4.2.1 The details of IEC activities conducted by the States are given in Table-8

4.2.1 The details of IEC activities conducted by the States are given in

Table-8

S.N	Particulars	Punjab	Haryana	UP	Total
1	Advertisement in Print media	167	50	150	367
2	Award for village/ Gram Panchayat for achieving zero stubble burning	95	0	0	95
3	Awareness programme (camp/ kisan mela etc.) conducted (i) State level (ii) District level (iii) Block level (iv) Village Panchayat level	4059	7975	8019	20053
4	Column / Articles in newspapers and magazines etc.	31131	125	0	31256
5	Hording fixed (at Mandi/Road side/ Market/ Schools/Petrol pump/ Panchayat etc.)	128037	5179	1328	134544
6	Poster/Banner placed at different location/buses/wall writing etc.	382045	1329	15204	398578
7	Publicity material such as leaflets/pamphlets etc. distributed	894939	1500000	0	2394939
8	(i) Jingles on radio/TV (ii) Scroll message on TV (iii) Audio -Visual clips on TV	975074	1	212	975287
9	Mobilization of schools and colleges students through essay competition, painting, debate etc. (Nos.)	419	15000	25000	40419
10	Demonstrations conducted (ha)	3007	3346	50	6403
11	Nos. of farmers trained	12500	8171	586	21257
12	TV programmes / panel discussions on Doordarshan/ DD- Kisan and other private channels	28	02	0	30



4.2.2 The DAC&FW has also telecasted 8 different scrolls on in-situ crop residue management on DD News and DD Kisan Channels. Two films, one each of 3.5 minutes duration and 1.5 minutes duration have been telecasted on DD Kisan, DD News, DD National and regional channels of Doordarshan such as DDK Hisar, Jalandhar and Gorakhpur. Also participated in the "Vaad Sanvaad" Programmes on DD Kisan.

4.2.3 The funds amounting to Rs. 21.29 crores were provided to the ICAR during 2018-19 for IEC activities. These activities have been implemented by ICAR through 60 Krishi Vigyan Kendras (KVKs) of

Punjab (22), Haryana (14), Delhi (1) and UP (23).

4.2.3.1 KVKs organized 416 capacity building programmes, in which more than 16,000 farmers, machine/tractor operators and other stakeholders were trained on use of machinery for *In-situ* crop residue management.



4.2.3.2 For creating awareness about this scheme, 661 awareness camps were organised in which 72,550 farmers were motivated to adopt In-situ crop residue management technologies.



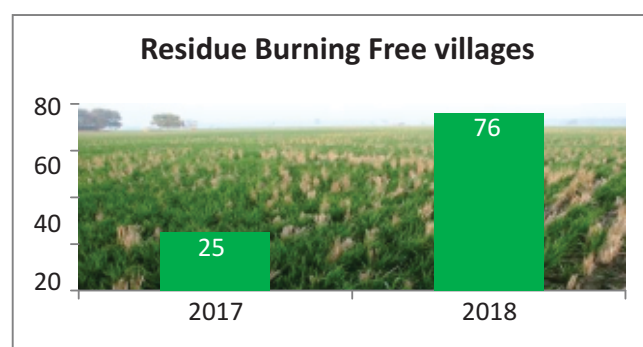
4.2.3.3 KVKs also organised 68 Kisan Mela in which more than 1.6 lakh farmers and other stakeholders were mobilized. Further, more than 40,000 school and college students were mobilized for creating awareness about this scheme.



4.2.3.4 To showcase the benefits of In-situ crop residue management, demonstrations on 12019 hectares were laid out at 19769 farmers' field in Punjab, Haryana, Delhi and Uttar Pradesh.

4.2.3.5 Keeping in view the influence of religious saints in Indian society, KVKs took the help of religious leaders in spreading the message of zero stubble burning which has shown very encouraging results.

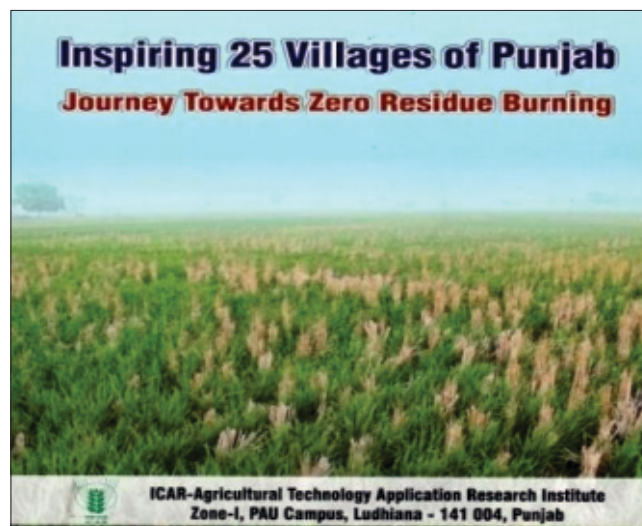
4.2.3.6 In 2017, KVKs of Punjab converted 25 villages as Zero Stubble Burning villages whereas in 2018, the number of Zero Stubble Burning villages increased to 76.



4.2.3.7 Hon'ble Prime Minister recognised Real Champion of Mission 'Zero Burning': Shri S.Gurbachan Singh has close coordination with Krishi Vigyan Kendra, Tarn Taran (Punjab) and ICAR-ATARI, Ludhiana. He regularly visits the KVK campus to gain first hand latest knowledge regarding agriculture and livestock farming. It is pertinent to mention here that Shri S. Gurbachan Singh first time narrated the incidence of fixing marriage of his son on the condition that bride's father will not burn crops residue on his farms during the "Stakeholders Meet at ICAR-ATARI, Ludhiana on 15th March, 2018" which was shared with media and consequently it reached the PMO. Hon'ble Prime Minister of India, Sh. Narendra Modi recognised

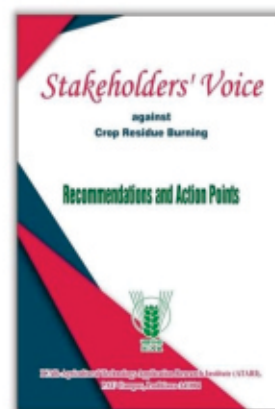
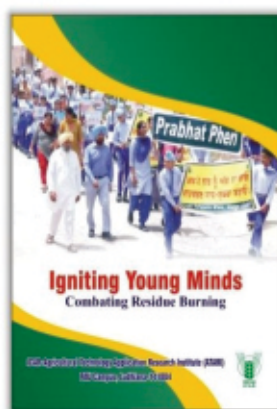
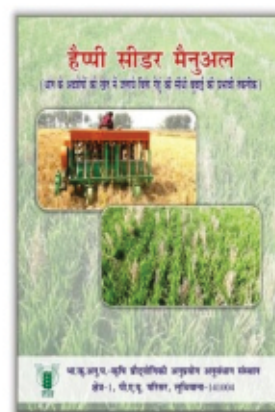
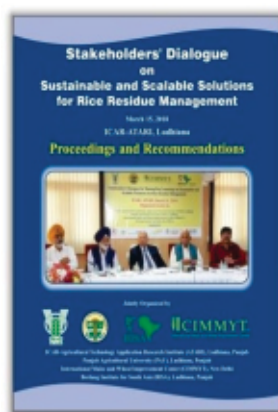
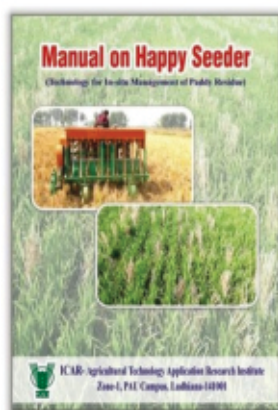
the contribution of Shri S. Gurbachan Singh's efforts in paddy straw management in Mann Ki Baat (Episode 49, 28 October 2018) programme.

- 4.2.3.8 Hon'ble Prime Minister also recognised Kalar Majri village (near Nabha Tehsil of Patiala) for its dedicated work of residue management which was declared as Zero Stubble Burning Village in the convergence mode where KVK, Patiala and Agriculture department worked together for making this village Burning Free during 2017. He admired all farmers of this village for this unique work and urged others to follow the path shown by Kalar Majri.

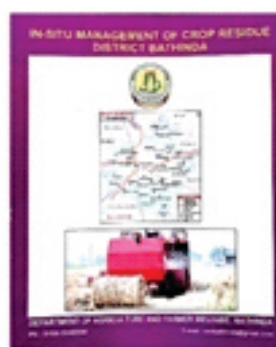
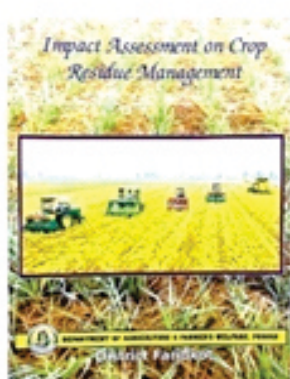
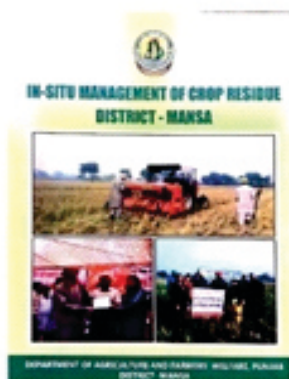
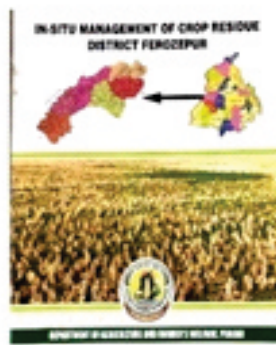
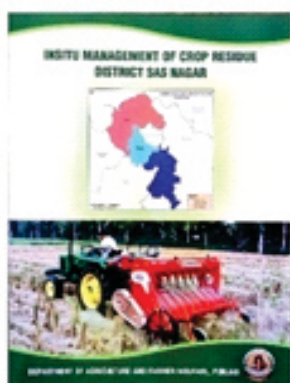
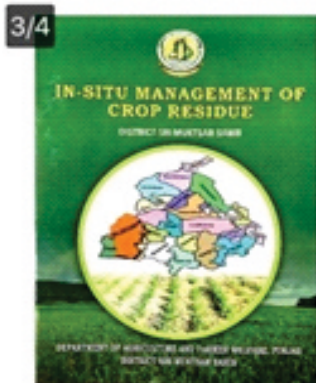
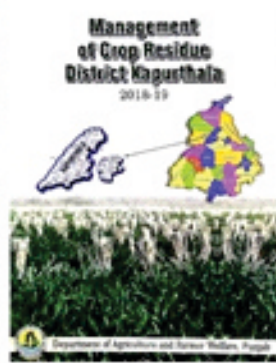
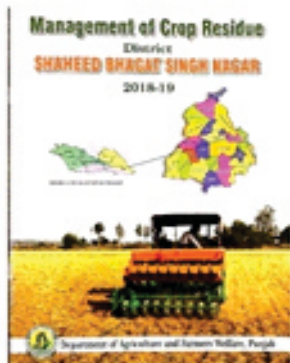
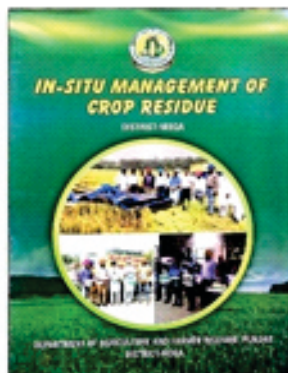
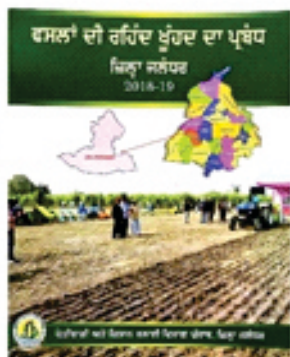


- 4.2.3.9 **Publications :** To create awareness amongst all stakeholders, several extension publications on In-situ crop residue management like pamphlets, operational manual of machinery, inventory of happy seeder, etc were published and provided to the farmers, machine operators, KVKs, etc. Several activities carried out under In-situ crop residue management project by KVKs are also well documented and published (a total of 25 publications published, title page enclosed). A documentary film on *In-situ* crop residue also developed by different ATARIs in Hindi and Punjab language.

Publications on *In-situ* Crop Residue Management by ICAR-ATARI, LUDHIANA



Assessment report on In-situ CRM by Various Districts of Punjab



4.3 Other Administrative Measures taken by the State Governments:

4.3.1 The Government of Punjab, in the Department of Science, Technology & Environment issued administrative instructions dated 27th September 2018 to various Departments with a view to control the burning of crop residue. The gist of the Government instructions is mentioned below:-

(A) Department of Personnel:

- i. Government Employees in various Departments of the Government, Corporations, Boards and Autonomous Bodies directed not to burn crop residue wherever they are growing Paddy.
- ii. They were also directed to dissuade others from indulging into the malpractice.
- iii. The employees should bring the matter to the notice of concerned authorities, in case there is any burning of crop residue in violation of orders of various Hon'ble Courts.
- iv. Failure to implement these instructions shall call for disciplinary action against such employees as per the service rules.

(B) Department of Education:

- i. Teachers/Staff members of the Government/Private Schools were directed not to burn crop residue wherever they are growing paddy.

- ii. They should dissuade others indulging into this malpractice.
- iii. They should bring the matter to the notice of concerned authorities, in case there is any burning of crop residue in violation of orders of various Hon'ble Courts.
- iv. The violation of these instructions should be viewed seriously and delinquent officials should be made liable for disciplinary action as per the service rules.

(C) Department of Irrigation:

- i. Canal Patwaries directed to bring the incidents of Paddy residue burnings to the notice of the respective Deputy Commissioners of the District for necessary action.
- ii. They were also directed to dissuade others from indulging in this malpractice.

(D) Department of Co-operation:

- i. All the members of Primary Co-operative Societies in Punjab were directed not to burn crop residue wherever they grow Paddy.
- ii. They have been also directed to dissuade others from indulging in this malpractice.
- iii. The violation of these instructions should be viewed seriously and concerned members be made liable for action under the relevant law.

(E) Department of Power:

- i. All the Junior Engineers of PSPCL in Punjab in rural area to remain present in their field jurisdictions and report the incidents of paddy residue burning to the notice of the respective Deputy Commissioners for further action.
- ii. They were also directed to dissuade the farmers from indulging in to this malpractice.

(F) Department of Agriculture:

- i. All the Commission Agents (Artiahs) registered with Agriculture Produce Market Committees in Punjab be directed not to burn crop residue in case they are growing Paddy.
- ii. They be also directed to dissuade the others from indulging in to this malpractice.
- iii. They should bring the matter to the notice of concerned authorities, in case there is any burning of crop residue in violation of various Hon'ble Courts. The violation of these instructions will make them liable for action as per relevant Law.

(G) Department of Revenue & Rehabilitation:

- i. All Revenue Patwaries directed to enter in girdawri register with red ink in whichever field, the burning of paddy straw takes place. The burning of paddy residue in that particular field would also be brought to the notice of his

- ii. Deputy Commissioners directed that if any Nambaradar is found indulging in straw burning, then he shall be issued notice by the Competent Authority for action against him/her.

(H) Department of Rural Development and Panchayats:

The Department of Rural Development and Panchayats was requested that it should ask the elected members of Panchayat to take pledge as per the format, separately sent, at the earliest and definitely before the start of harvest.

(I) All Deputy Commissioners:

- i. The Deputy Commissioners and SSPs were asked to jointly hold meetings with all the stakeholders to strictly enforce the orders banning Paddy stubble burning.
 - ii. Environmental Engineers of Punjab Pollution Control Board were directed to work in close coordination with Deputy Commissioners and to take prompt action in case there is any violation of straw burning ban orders.
- (F) Nodal officers numbering about 8000 were appointed at the village level to create awareness amongst the farmers against paddy residue burning.**

4.3.2. The Government of Haryana also for effective implementation of the scheme has taken the following measures:

- (i) Haryana state has notified on 19.06.2018 the State Level Monitoring Committee (SLMC) under the chairmanship of Chief Secretary, Haryana and consisting the administrative secretaries of various concerned departments as members.
- (ii) Haryana state has also notified on 19.06.2018 District Level Monitoring Committee (DLMC) under the chairmanship of Deputy Commissioner and other stakeholders department as members.
- (iii) The state has designated SDMs in the districts as nodal officer at Sub Division Level for the supervision, monitoring and regulation of the entire scheme for prevention of crop residue burning.
- (iv) Mobile squads were constituted to monitor the burning events in every tehsil/block under the supervision of Sub Divisional Officer/Magistrate and make them responsible for ensuring that no stubble burning takes place.
- (v) The district level committees consisting the staff of Haryana State Pollution Control Board,

staff of Revenue Department, Panchayat Department and Agriculture & Farmers Welfare Department were deployed for imposing penalty on the farmers those who burnt the paddy straw. The Revenue Department has identified 1058 cases for imposing penalty and First Information Report (FIR) has been lodged in 164 cases. The compensation of Rs. 31.82 lakhs has also been collected.

The gist of work done by various other department and stake holders is as below:

(A) Department of Education:

- (i) Teachers/Staff members of the Government/Private Schools were directed to generate awareness amongst the parents through the students.
- (ii) They should dissuade others indulging into this malpractice.
- (iii) They should bring the matter to the notice of concerned authorities, in case there is any burning of crop residue in violation of orders of various Hon'ble Courts. The violation of these instructions should be viewed seriously and delinquent officials should be made liable for disciplinary action as per the service rules.

(iv) The Principals/Head Masters of the schools were directed to conduct Painting and essay competition amongst the students to generate awareness.

(v) The message of not burning crop residue and oaths were undertaken during the prayers by the students.

(B) Department of Co-operation:

(i) All the members of Primary Co-operative Societies in Haryana were directed not to burn crop residue wherever they grow Paddy.

(ii) They have been also directed to dissuade others from indulging into this malpractice.

(iii) The Violation of these instructions should be viewed seriously and concerned members be made liable for action under the relevant law.

(C) Department of Power:

(i) The Department of Power has been requested to promote the use of minimum 5 % pellets in the coal based power generation thermal plants.

(ii) They were also directed to dissuade the farmers from indulging into this malpractice.

(D) Department of Agriculture:

(i) The Deputy Director Agriculture and other staff members were directed for awareness through village level/block level and district level camps.

(ii) Vide Demonstration and training to farmers were imparted at village level.

(iii) The staff members of the department were the part of the district level, block level and village level committees to control and monitor the straw burning.

(E) Department of Revenue & Rehabilitation:

(i) All Revenue Patwaries, Numbardar at village level were directed to report straw burning incidence to stop the burning at grass route level.

(ii) Deputy Commissioners directed that if any Nambardar is found indulging in straw burning, then he shall be issued notice by the Competent Authority for action against him/her.

(F) Department of Rural Development and Panchayats:

(i) The Department of Rural Development and Panchayats was requested that it should ask the elected members of

Panchayat to take pledge as per the format, separately sent, at the earliest and definitely before the start of harvest.

- (ii) In case the straw burning takes place on Panchayat Land it was requested to the department that the concerned cultivating person should be held responsible and should be debar from the lease of the Panchayat Land.

(G) All Deputy Commissioners:

- (i) The Deputy Commissioners and SSPs were asked to jointly hold meetings with all the stakeholders to strictly enforce the orders banning Paddy stubble burning through the district/block/village level committees and should review weekly and report to Chief Secretary during the weekly review meeting.

4.3.3. The Department of Agriculture, Government of Uttar Pradesh have taken the following Administrative measures to stop the paddy straw burning-

(A) Department of Agriculture banned crop burning and issued order :-

- Agriculture department issued order that if any farmer is found burning crops he will be monetarily penalized. About Rs. 17.5 Lakhs collected as fine last year.

- Wide spread advertisement through print media to stop people from burning crops.
- Jingle was also broadcast on TV and FM radio.
- Department with the help of Rural Development Department is encouraging people for making compost with crop residue by digging pits from MGNREGA funds.
- Wall painting in majority of villages showing harmful effects of crop burning and farmers were made aware of ill effects of crop residue burning.
- Agriculture department made it compulsory that for harvesting of crop, if combine harvester is used then it should be along with straw reaper. If any person found violating this, he will be penalized, and civil suit will be filed against him. An action has been taken in Lalitpur district.
- Farmers were also made aware of through the Million Farmers School Programme.
- Through the GO detail instructions was issued by Chief Secretary to all the concerned Departments in reference to control environmental pollution from burning crop residue. Mobile squad under the leadership of SDMs was formed to monitor crop residue burning.
- A state level farmers awareness camp/workshop was organized on crop residue burning during Krishi

Mahakumbh. In Krishi Mahakumbh about 2.5 lakhs of farmers from different parts of the state participated and they were made aware about disadvantage of crop residue burning and advantage of crop residue management through the lecture delivered by different Scientists and live demonstration of CRM implements.

(B) Department of Revenue

- All District Magistrate have been directed by government that punitive action should be taken if any person is found violating government orders and for this help of SDMs be taken.
- Remote Sensing Application Centre has been entrusted with the task of preparing a fire alarm system.
- GO have been issued for prohibiting agriculture crop residue burning and DMs were directed that notifications are enforced rigorously and proper action is taken against the defaulters. Any person or body found offending this direction would be liable to pay environmental compensation.

(C) Department of Education

- Teachers of the schools were directed to teach the students ill effects of crop residue and request their parents through them not to burn crop residue.

- A painting competition was organised at school level to make student and their parents aware of disadvantage of crop residue burning.
- Rallies were also organised through school for awareness.

(D) Department of Personnel

- Government employees of all the departments were directed to guide farmers not to burn crop residue.
- They were also asked to bring it to the notice of concerned SDMs or Agriculture department officials whenever they found such cases of crop burning.

(E) U.P. Pollution Control Board

- Department of Environment and pollution through gazette notification has banned crop residue burning for controlling environmental pollution under its act of 1981.
- All DMs have been issued order to implement this effectively.
- All DM have been directed to prepare a Crop Residue Management plan and get it implemented effectively.
- An order is issued to Brick Klin owners that atleast 20% of the fuel used by them should be from Bio Briquette.
- Order is also issued by the department to recover losses as fine from defaulters.

- (F) **Finance Department**
- The department created a separate head for the deposit of fines collected for environment loss recovery.
- (G) **U.P. Bio Energy Development Board**
- A plan has been prepared by U.P. Bio Energy board for making bio bricks from crop residue.
 - A subsidy 25 % is given on a project of 25 lakh and for project from 25 lakh to 10 crore interest subvention is given.
 - About 20000 leaflets have been printed and sent to gram pradhan through Panchayati Raj Department.
- 4.4. The governments of Punjab and Haryana have been working with the farmers, agricultural universities and ICAR institutions to prevent burning of crop residue and promote CRM machinery. With the inception of the new scheme on Agricultural Mechanization for in-situ Management, these efforts have been significantly expanded. The IEC campaigns were run extensively. Many non governmental organizations including industrial associations like CII, Birla Foundation and others have also joined hands to take forward the message of incorporating paddy straw in the field. In addition,

Haryana imposed fines on some of the farmers to send a strong message that crop residue burning would not be tolerated in the State. There is enough scientific evidence now to indicate that conservative farming through happy seeder and other CRM machines is not only more cost effective option but also improves soil health, augmenting farmers incomes in the medium term. The Committee recommends that IEC campaign through various media be continued during August to October, 2019 period.

CHAPTER - V

ASSESSMENT AND IMPACT OF THE MACHINERY USED BY THE FARMERS & ASSESSMENT OF THE BENEFITS ACCRUED TO THE FARMERS.

- 5.1 In the State of Punjab, the area managed by different in-situ crop residue management machinery provided during 2018-19 was 1602822 ha. However this is not a cumulative figure as on the same plot 2 or more than 2 machines could have been used. The area managed by the happy seeders was 449529 hectares. The district-wise details of area managed by different machines is at **Annexure-XI**.
- 5.2 In the State of Haryana, the area managed by different in-situ crop residue management machinery provided during 2018-19 was 705023.4 Acres and about 133955 farmers have been benefitted by this. The area managed by the happy seeders was 134707.5 Acres and the farmers benefitted by the use of Happy Seeders were 12456 numbers. The district-wise details of area managed by different machines is at **Annexure-XII**
- 5.3. The use of CRM machinery, especially Happy Seeder which is used for sowing wheat is a major indicator of success of the new schemes on management of paddy straw. Different machineries distributed across districts in Punjab and Haryana and area covered by these machines is indicated in Annexures. The area covered by different machines is not cumulative in the sense that to cultivate a unit of land, 2 or 3 machines permissible under the new scheme could be used, especially in sowing of potato. However, Happy Seeder can be used as a stand alone machine for sowing wheat in farms which have paddy stubble and paddy straw on the field. Information on the number of happy seeders provided in a district and area sown through happy seeder in that district for few districts of Punjab and Haryana is reported below.
- Use of CRM Machinery in Punjab & Haryana is given in Table-9 & Table-10, respectively.

Table-9

District	Area (Hect.)	Number of Happy Seeders	Area covered by one Happy Seeder (Hect.)
Bhatinda	23000	883	26.04
Sangrur	77300	105	73.62
Muktsar	34722	361	96.18
Faridkot	31151.2	367	8.48
Firozpur	29400	512	57.42
Ludhiana	51206	1038	49.33

Table-10

District	Area (Hect.)	Number of Happy Seeders	Area covered by one Happy Seeder (Hect.)
Jind	7072	227	31.15
Kaithal	6700	222	30.18
Yamunanagar	5684	104	54.65
Karnal	2899	215	13.49
Sirsa	2435	341	7.14
Fatehabad	3374	522	6.46

There is a marked difference in utilization of happy seeders across the districts in Punjab. It ranges from 8.48 hectares to 73.61 hectares. Similarly, in Haryana in Sirsa, on an average, only 7.14 hectares was sown through happy seeder while in Yamuna Nagar, it was 54.65 hectares. A low coverage of area through happy seeder points to severe underutilization of an expensive capital equipment. One reason for low utilization was reluctance of farmers to switch over to sowing by happy seeder on a large scale on account of their apprehensions of this new technology. The other reason which Committee come across, especially in Sirsa was, that after a initial one or two days, happy seeders developed snags and lack of after sales support from the vendor left farmers with no other option but to resort to crop burning and traditional method of sowing. The other major reason was delayed delivery of happy seeders. It is necessary that strong IEC campaign to popularize the new technology is backed with strong after sales service by the vendors. Both the

State Governments would need to frame rules on after sales service and work out an incentive/disincentive mechanism for machinery suppliers so that they invest in after sales service. Another point that has an impact of usage of happy seeder is the training of operator's who operate happy seeders. The operator's have to be properly trained in use of happy seeder for sowing of wheat. This point was brought to the notice of the Committee by a Farmer Producer Organization which is being assisted by a team of Confederation of Indian Industry (CII) who are supporting crop residue management initiative in 19 villages in three clusters in Ludhiana and Patiala districts of Punjab.

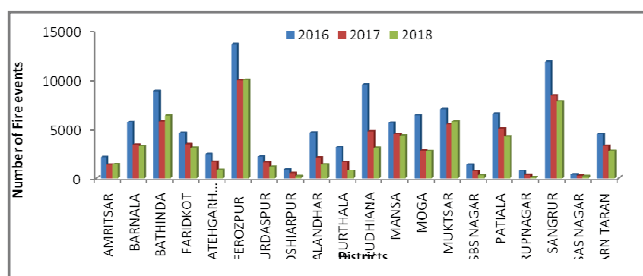
5.4. Impact of Machinery Use on Crop Residue Burning:

5.4.1. Paddy residue burning was monitored by multiple satellites with thermal sensors during the harvest period from 1-Oct to 30-Nov in the states of Punjab, Haryana and Uttar Pradesh by the

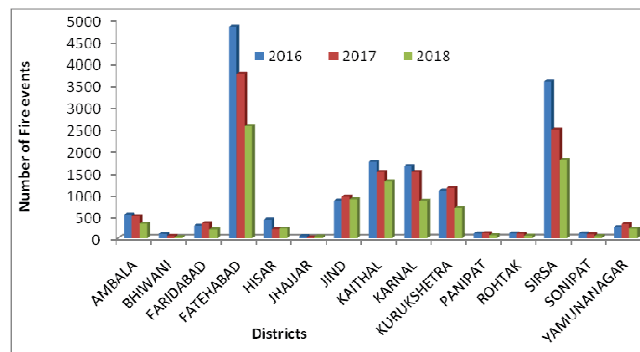
Consortium for Research on Agro ecosystem Monitoring and Modelling from Space(CREAMS) Laboratory, Division of Agricultural Physics, ICAR - Indian Agricultural Research Institute, New Delhi

5.4.2 High resolution satellite images at 20m were acquired for pre-burning and post burning period to map paddy acreage and paddy area burnt in 20 districts of Punjab and 10 districts of Haryana during 2018. The area statistics were used to estimate paddy straw burnt.

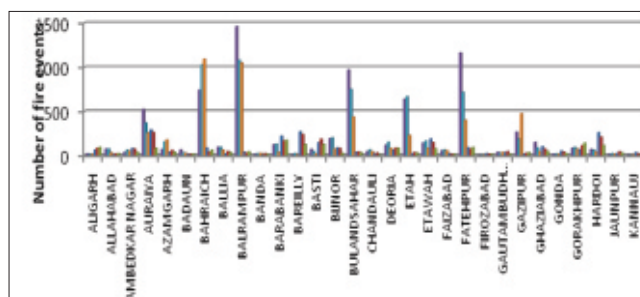
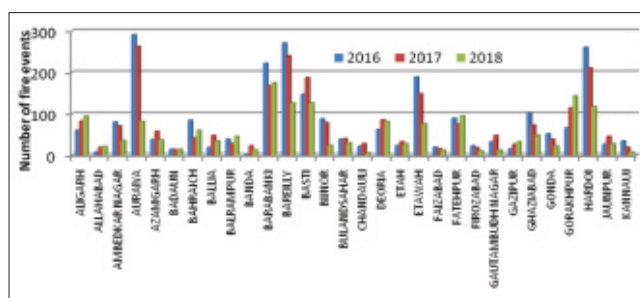
5.4.3 The District-wise comparison of burning events of the last 3 years in Punjab is shown in the figure below and district-wise percentage reduction in burning events in 2018 in comparison 2016 & 2017 are given in **Annexure XIII**



5.4.4 The District-wise comparison of burning events of the last 3 years in Haryana is shown in the figure below and district-wise percentage reduction in burning events in 2018 in comparison 2016 & 2017 are given in **Annexure XIV**



5.4.5 The District-wise comparison of burning events of the last 3 years in Uttar Pradesh is shown in the figure below and district-wise percentage reduction in burning events in 2018 in comparison 2016 & 2017 are given in **Annexure XV**.



5.4.6 The observations on the fire events in all the three States (Punjab, Haryana & Uttar Pradesh) are summarized as under:

- For the three states, burning events detected were 127774, 88948, and 75563 in the years 2016, 2017 and 2018 respectively.

- Overall, about 15% and 41% reduction in number of burning events were observed in current year (2018) as compared to that in 2017 and 2016, respectively.
- Of the 75563 burning events detected in the three States between 01-Oct-2018 and 30-Nov-2018, these were distributed as 59695 (79%), 9232 (12%) and 6636 (9%) in Punjab, Haryana and UP, respectively.
- The majority of burning happened between 27-Oct and 09-Nov in the three states.
- There was significant correlation (above 0.9) between number of burning events detected by thermal remote sensing and burnt area estimated by high resolution remote sensing.
- About 23 Million tons of GHGs (Green House Gases) and Particulate matter (PM) was estimated to be emitted from paddy residue burning in the three states in 2018.
- Of the 23 Million tons of GHG and PM emission in 2018, Punjab contributed 83%, Haryana contributed 11% and UP contributed 7%.
- Of the total emissions, CO₂ contributed 93.7% of the pollutants.

5.4.7. The State-wise summary of the fire events is as under:

(A) PUNJAB

- The burning events detected were 102379, 67079, and 59695

in the years 2016, 2017 and 2018, respectively.

- About 11.01% and 41.69% reduction in number of burning events were observed in current year (2018) as compared to that in 2017 and 2016, respectively.
- For 20 major paddy growing districts, remote sensing estimated 2.96 Mha area planted, out of which 1.51 Mha area was burnt in 2018.
- About 51% of the paddy planted area reported burning.
- For 20 major paddy growing districts, remote sensing estimated 25.48 Mt of paddy straw produced on dry weight basis, out of which 11.81 Mt was burnt in 2018.
- About 46.4% of paddy straw was burnt in 2018.
- Ferozpur, Sangrur and Muktsar districts reported highest paddy area burnt and highest burning events in 2018.
- Bhatinda, Firozpur, Muktsar, Mansa, Fazilka and Faridkot districts reported burning in more than 70% of their paddy area in 2018.

(B) HARYANA

- The burning events detected were 15686, 13085, and 9232 in the years 2016, 2017 and 2018, respectively.

- About 29.45% and 41.15% reduction in number of burning events were observed in current year (2018) as compared to that in 2017 and 2016, respectively.
- For 10 major paddy growing districts, remote sensing estimated 1.04 Mha area planted, out of which 0.23 Mha area was burnt in 2018.
- About 22.12% of the 1.4 Mha paddy planted area in 10 districts reported burning. Whereas for the whole state against the area of 14.4 lakh ha the percentage is 15.9% paddy planted area reported burning.
- For 10 major paddy growing districts, remote sensing estimated 7.55 Mt of paddy straw produced on dry weight basis, out of which 1.60 Mt was burnt in 2018.
- About 14.04% of paddy straw was burnt in 2018.
- Fatehabad and Sirsa districts reported highest paddy area burnt in 2018 and their paddy area burnt was 70.6% and 61.6%, respectively

(C) UTTARPRADESH

- The burning events detected were 9709, 8784, and 6636 in the years 2016, 2017 and 2018, respectively.
 - About 24.45% and 31.65% reduction in number of burning events were observed in current year (2018) as compared to that in 2017 and 2016, respectively.
- 5.5. The incidents of crop burning have come down significantly in Haryana in 2018. The reduction was more modest in Punjab. The district-wise analysis of incidents of burning indicate that in Haryana the districts which had reported high incidences of burning in 2016 and 2017 recorded impressive reduction in straw burning in 2018. Fatehabad, Karnal, Kurukshetra and Sirsa which accounted for major share of the crop burning in Haryana were able to control incidents of paddy straw burning by providing CRM machinery. This was also followed by strict monitoring by district administration for preventing the incidents of paddy straw burning. In Punjab also districts like Kapurthala, Ludhiana, Jalandhar recorded impressive gains in preventing paddy straw burning. However, districts like Barnala, Faridkot, Mansa which saw large scale burning in 2016 and 2017 had very small reduction in incidents of crop burning. The committee was informed by some faculty members of Punjab Agricultural University, Ludhiana who have been closely associated with the projects that though the incidents of crop burning were high

in 2018, the area that was subjected to burning was much lower compared to last year.

The Reason for high number of fire incidents in their opinion was that in October and November, 2018, there were frequent rains and farmers started fire in the same field at different locations

to ensure the paddy straw was fully burnt. This was also confirmed by some of the farmers in Bhatinda and Sangrur. In effect this means that even if the number of fire incidents have not come down in these districts, the intensity of burning and the quantum of paddy straw burning in 2018 was much lower.

CHAPTER - VI

PADDY VARIETIES FOR PROMOTING BETTER STRAW MANAGEMENT

6.1 Paddy Varieties:

6.1.1 Quantity of Paddy straw and its subsequent management depends to a large degree on the variety of Paddy that is cultivated. Different varieties have different maturing periods. The early maturing varieties allow a longer time period for sowing of wheat and other Rabi crops. Longer time period allows farmers to incorporate Paddy straw in the soil for growing Potato or other vegetables. In case of wheat, early maturing paddy varieties enable a farmer to sow wheat at the optimal planting time around 5th November. It also allows farmers to manually or mechanically remove paddy straw from the field for cultivating next crop, if the farmer so desired.

6.1.2 Paddy could be broadly classified as Basmati and non-Basmati. This classification is important. Basmati Paddy continues to be harvested manually, which does not leave any Paddy straw on the field. This position may, however change in the coming years as labour shortages become acute. The Committee did come across a few farmers in Haryana (Hissar District) who used combined Harvester to harvest Pusa 1509, a Basmati variety, as labour for harvesting, when the crop was ripe, was not available.

6.1.3 The table below indicates area under Paddy and area under Basmati Paddy for the periods 2016 to 2018. Area Under Basmati Paddy (in 000 Hectares) is given in Table -11

Table-11

State	2016		2017		2018	
	Total Paddy	Basmati	Total Paddy	Basmati	Total Paddy	Basmati
Punjab	3010.0	615.6	2865.6	561.2	2863.0	549.0
Haryana	1303.1	719.6	1273.7	652	1278.8	631.7

Source : Basmati Survey Report -APEDA, 2017,2018

6.1.4 In Haryana roughly 50% of the Paddy cultivation is of Basmati variety. Punjab on the other hand, which has close to 3 million hectares under Paddy, has only 19% of its area under Basmati variety (2018). Since 2015, area under Basmati varieties has gone down

significantly, especially in Punjab, because of fluctuating prices of Paddy in international market. Cultivation of Basmati in Punjab is also concentrated in Amritsar, Fazilka, TaranTaran and Muktsar districts, though other districts also grow Basmati on smaller scale.

However, the districts which reported high incidence of straw burning in 2017-18 such as Bhatinda, Barnala, Mansa and Fatehgarh Sahib have very small area under Basmati. These are also the districts which grow Pusa 44, currently longest maturing variety in Punjab leaving a very small window of 5 to 10 days to farmers for harvesting of Paddy and sowing of Wheat/other Rabi crops.

6.1.5 On-going research at Punjab Agricultural University, Ludhiana has lead to the development of short to medium duration varieties and has recommended 6 varieties of paddy for general cultivation in the state since 2013.

6.1.6 The salient features of paddy varieties recommended for cultivation in the Punjab State are given in Table - 12

Table-12

Variety	Year of release	Average yield (q/ha)	Days to maturity (after transplanting 30 days nursery)	Resistant to bacterial blight pathotypes
PR 127	2018	30.0	107	10/10
PR 126	2017	30.0	93	7/10
PR 124	2015	30.5	105	10/10
PR 123	2014	28.0	113	10/10
PR 122	2013	31.5	117	10/10
PR 121	2013	30.5	110	10/10
Pusa 44	-	32.0	130	0/10
HKR 47	2005	26.0	105	-
HKR 48	2014	24.0	88	-
Gobind	-	21.0	90	-

6.1.7 Interaction with farmers has revealed that the load of rice residue as well as the availability of window period between sowing of wheat crop and harvesting of rice crop are the major factor determining its management. For instance, crop residues of short duration/ early maturing varieties or those having higher harvest index can be managed quite efficiently with various resource

conservation technologies recommended by Punjab Agricultural University, Ludhiana. Farmers tend to resort to burning the residue of long duration varieties owing to shorter window availability for sowing of next crop as well as higher residue load of these varieties. The window period allowed by different rice varieties, between rice harvest and wheat sowing is given in Table - 13.

Table-13

Variety	Recommended transplanting time	Days to maturity (after transplanting 30 days nursery)	Approximate harvesting time	Window period for optimum sowing time* (days)
PR 126	25 June -5 July	93	25 September -7 October	28 to 40 days
PR 124	25 -30 June	105	8-13 October	22 to 27 days
PR 127	25 -30 June	107	10-15 October	20 to 25 days
PR 121	20 -25 June	110	8-13 October	22 to 27 days
PR 122	20 -25 June	117	15-20 October	15 to 20 days
Pusa 44	20-30 June*	130	30 October-10 November	0 to 5 days

*Optimum sowing of wheat up to 5 November

6.1.8 Despite short duration varieties providing a larger window for paddy straw management, the selection of long duration varieties by farmers is associated with the perception that owing to their higher yield, they are more profitable. This perception is not borne out when we evaluate the

economics of growing these varieties by taking into account various inputs and operations costs.

Performance of PAU recommended paddy varieties over Pusa 44 is given in Table-14

Table-14

Item	PR 126 (93 days)		PR 121 (110 days)		Pusa 44* (130 days)	
	Quantity	Value (Rs)	Quantity	Value (Rs)	Quantity	Value (Rs)
Main Product (q/acre)	30.1	47859	30.9	49131	32.6	51834
Variable Costs:						
Nursery raising	-	665	-	670	-	700
Fertilizers	-	1082	-	1139	-	1388
Plant Protection	-	1652	-	1925	-	3063
Irrigations (No.)	25	1625	29	1885	34	2210
Human Labour (Hours)	130	5200	138	5520	156	6240
Tractor Hours	6.5	2795	7	3010	8	3440
Combine Harvesting	-	1250	-	1250	-	1250
Marketing Charges	-	487	-	501	-	525
Interest on variable costs @ 9% for half period	-	332	-	358	-	423
Total variable costs	-	15088	-	16258	-	19239
Returns over variable costs	-	32771	-	32873	-	32595

*Un-recommended variety

Note: Due to higher straw load of Pusa 44 the tractor use is more than other varieties

6.1.9 During interactions with the farmers, it also transpired that their choice of variety also depends to a considerable extent on the willingness of the rice millers in their area to procure their Paddy for milling and subsequent delivery to FCI. It was pointed out that PR 126, which is the earliest maturing variety had a higher brokerage percentage during milling. There were reports that many millers had taken out press advertisements in the month of May to discourage farmers from planting PR 126 as they would not procure this variety. Punjab has a strong network of more than 3600 rice mills and they play a major role in the varieties that the farmers grow.

6.1.10 The cultivation of short duration varieties such as PR 121 and PR 126 offer scope for adoption of multiple cropping systems i.e. taking three crops a year, which is not possible with long duration varieties. By adding third crop in the cropping system, farmers can enhance their farm income. The inclusion of leguminous crops such as summer moong/peas will also help in improving soil health and saving of nitrogen in the next crop in cropping system. Economic evaluation of some important cropping systems with different paddy varieties in Punjab (Based on field survey) (Rs/acre) is given in Table - 15

Table-15

Cropping system	Crop	Average yield (q/acre)	Gross returns# (including by product)	Total variable costs	Return over variable costs
Paddy (PR 121)-Potato-Summer moong	Paddy (PR 121)	30.9	49131	16258	32873
	Potato	118.7	59350	36294	23056
	Summer moong	4.7	21150	9542	11608
	Total		129631	62094	67537
Paddy (PR 126)-Potato-Wheat	Paddy (PR 126)	30.1	47859	15088	32771
	Peas	26.1	49590	33029	16561
	Wheat	15.0	27375	13062	14313
	Total		124824	61179	63645
Paddy (PR 126)-Potato-Wheat	Paddy (PR 126)	30.1	47859	15088	32771
	Potato	83.7*	41850	29004	12846
	Wheat	14.8	27050	13062	13988
	Total		116759	57154	59605
Paddy (PR 126)-Wheat	Paddy (PR 126)	30.1	47859	15088	32771
	Wheat	19.6	36050	14862	21188
	Total		83909	29950	53959
Paddy (PR 121)-Wheat	Paddy (PR 121)	30.9	49131	16258	32873
	Wheat	19.6	36050	14862	21188
	Total		85181	31120	54061
Paddy (Pusa 44)-Wheat	Paddy (Pusa 44)	32.6	51834	19239	32595
	Wheat	19.6	36050	14862	21188
	Total		87884	34101	53783

*Early harvesting

* Calculated on the basis of average price of produce obtained by farmer

- 6.1.11 Since the development of short duration varieties and extension efforts for their adoption, the area under these short duration varieties is on rise in Punjab during the last few years.

Adoption of recommended short duration varieties in Punjab over years is given in Table - 16

Table-16

Year	2012	2013	2014	2015	2016	2017	2018
Recommended short duration varieties (%)	26.7	29.1	26.0	38.7	61.6	68.3	73.9

Source: Punjab Agricultural University, Ludhiana.

- 6.1.12 Though, the short duration varieties have been well adopted by the farmers in the state but still in the districts of Barnala, Bathinda, Ludhiana, Mansa, Moga, Muktsar, Patiala and Sangrur, the adoption is slow and sizable area is under long duration varieties. The situation in Haryana is comparatively better as larger area in Haryana is under Basmati rice which does not pose the problem of straw burning at present. However, in districts such as Hissar, Fatehabad, Paddy variety known as Mulcher in the local area, is grown extensively. The duration of this variety is similar to Pusa 44 leading to burning of Paddy straw residue to clear the field for next crop.

- 6.1.13 The short duration varieties of Paddy developed by PAU have already spread to more than 70% of the area in Punjab. These varieties need to be promoted by providing their seeds and carrying out the extension activities in Punjab and Haryana in an intensive manner. The Government of India could also consider banning Pusa 44 for cultivation in these areas. The biggest advantage of early

maturing varieties of Paddy is that with adoption for happy seeders for showing of wheat in Punjab and Haryana, farmers would be able to sow wheat before 5th November, the ideal sowing time for wheat and would be able to reap higher production with lower cost, since plantation at the optimal time will reduce irrigation demand and also protect wheat crop from high temperatures obtaining in March/April. The early maturing varieties therefore should be promoted both in Punjab and Haryana.

6.2

Alternative to Paddy Cultivation:

Maize can be alternate to the Paddy cultivation in Punjab & Haryana. However, Maize as a Kharif crop is less assured against paddy in terms of production and procurement because of the following:

- Uncertainty in stand establishment
- More vulnerability to biotic and abiotic stresses
- Comparatively higher incidence of weeds and non-availability of highly effective selective herbicide

- iv) Uneven cob filling because of pollen wash if the flowering period coincide with a spell of continuous rains in monsoon season
- v) Lesser mechanization for maize harvesting
- vi) Less assured procurement after harvest

6.2.1 The dominating basmati varieties in Haryana and part of Punjab like PB 1121 and PB 1509 generally yield around 20-25 q per acre and average price they fetch in the market generally hovers around Rs 3000/ qtl. Therefore total return from paddy crop by growing these varieties comes to around $23 \times 3000 = \text{Rs } 69000$ per acre.

6.2.2 For common grade paddy variety like Pusa 44, the minimum support price of Rs 1750/q declared by the Govt of India for the year 2018-19 and the yield level of 28q/acre has been considered for calculating the total return, which comes around $28.0 \times 1750 = \text{Rs } 49000$. The yield level of both Basmati and common grade paddy variety has been assumed under the best management condition and production environment of Haryana and Punjab

6.2.3 With the available hybrids from public and private sectors of full season duration of Kharif maize, grain yield of around 26-27 qt per acre is achievable. However, this yield level has been assumed keeping in view the fact that large acreage under maize crop will lead to greater investment in research and development by both public and private sector in generation of effective plant protection measures against weeds, disease and insects in Kharif maize.

6.2.4 Keeping in view high water demand in rice crop, depleting water table, limiting labour supply for rice transplanting, the farmers can be incentivized to partially replace by offering assured price in the range of Rs 1950 to Rs 2050 per qt.

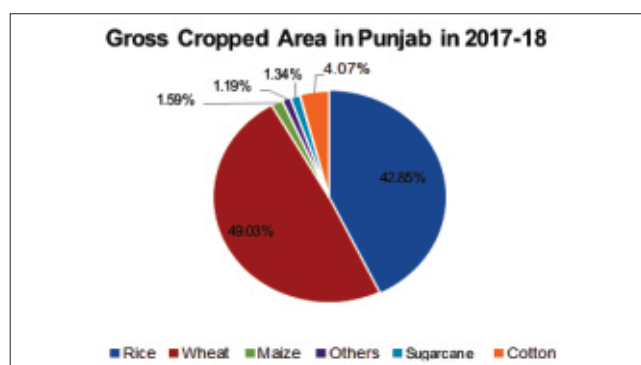
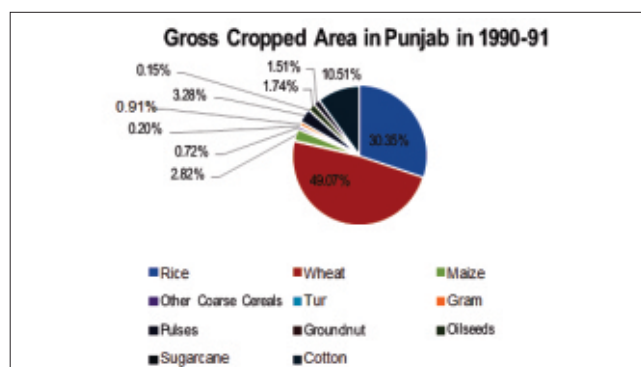
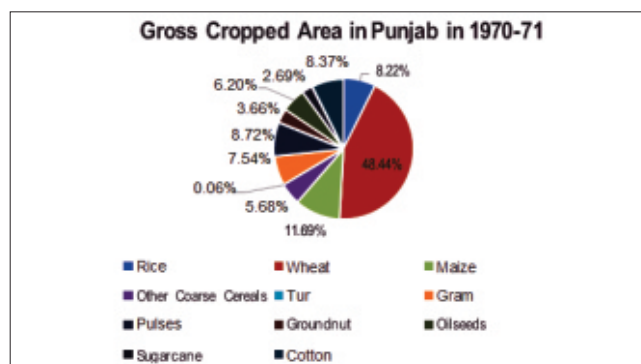
6.2.5 The price has been proposed to target only partial replacement of rice area by making maize equally competitive for economic return. Because of attractive price, farmers may start growing maize as spring crop in rice-potato-maize or rice-mustard-maize cropping system.

CHAPTER - VII

CROP DIVERSIFICATION

7.1 The cropping pattern in Punjab and Haryana has changed dramatically with the advent of Green Revolution in late 1960's. The acreage under wheat started increasing from 1967-68 onwards. The spurt in rice acreage in these two States occurred around 1974-76 periods when breakthrough in high yielding varieties of Paddy was made by the agricultural research system. The period from 1970-71 to 2018-19 presents a picture of increasing area under Paddy and wheat and almost secular decline in acreage under other crops. In Punjab, Paddy was grown in 3.90 lakh hectares in a few districts in 1970-71. In 2017-18, it was grown in 30.65 lakh hectares across the State. Similar is the story of wheat, though the increase in area during this period is not as dramatic as in case of paddy.

7.2 The paddy and wheat cycle in Haryana has taken an equally strong hold. Paddy which was cultivated in 2.69 lakh hectares in Haryana in 1970-71 was cultivated in 14.22 lakh hectares in 2017-18. Compared to Punjab, Haryana presents a more diversified cropping pattern, though the preponderance of paddy, wheat cropping cycle still stands out. The pie-charts given below indicate distribution of gross cropped area under major crops in Punjab.



Source : Directorate of Economic and Statistics, Gol.

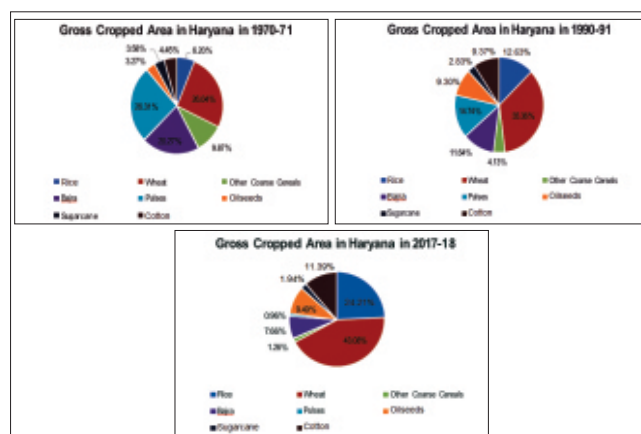
7.3 The analysis of cropping pattern in Punjab indicates complete domination of paddy and wheat cropping cycle and almost total elimination of many important crops. Bajara and gram have gone out of cultivation in Punjab. Pulses have a very small presence occupying only 0.43% of the gross cropped area in 2017-18.

Oil seeds have seen an equality dramatic reduction over the years, accounting for 0.43% gross cropped area in 2017-18. Oil seeds and pulses put together, are grown in only 0.86% of the GCA in 2017-18 as against 14.91% of the GCA in 1970-71. Only sugarcane and cotton in Punjab continued to be cultivated without substantial reduction till about 2010-11. This scenario seems to be changing in case of cotton as the white fly disease in Bt cotton in Punjab has affected productivity. Farmers have shifted to other crops, largely paddy, in Southern Punjab districts of Bhatinda, Mansa, Sangrur and Barnala.

7.4 It is not only that the other crops have lost acreage to Paddy and Wheat, the increase in gross cropped area has almost completely gone to Paddy and Wheat. Of the total gross cropped area under food grains, oil seeds, sugarcane and cotton in 2017-18, 91.89% of the GCA was under Paddy and wheat. There has been some crop diversification in Punjab during 1991-92 to 2017-18 period as cultivation of vegetables increased from 0.85 lakh hectares to 2.44 hectares. This seems to have come about as many erstwhile farm workers from Uttar Pradesh and Bihar have settled in Punjab are cultivating vegetables on leased land (Reported in Times of India, 4th April, 2019). However, in the overall crop pattern of Punjab, this was a very small step.

7.5 Haryana agriculture shows a more diverse cropping pattern inspite of dominance of Paddy - Wheat

cropping cycle. The pie charts given below indicate acreage at different points of time in Haryana. In Haryana also Kharif coarse cereal have lost acreage to Paddy but Bajara still continues to be grown in 4.5 lakh hectares as compared to 8.79 hectares in 1970-71. Pulses, however have lost acreage dramatically coming down to only 0.56 lakhs hectares in 2017-18 from a high of 11.41 lakh hectares in 1970-71. The heartening development in Haryana is increased acreage under oilseeds during 1970-71 to 2017-18 period, from 1.42 lakh hectares to 5.57 lakh hectares and cotton from 1.93 lakh hectares to 6.69 lakh hectares. Even in Haryana, in 2017-18, 67.30% of the GCA was under Paddy and Wheat, though lower than that in Punjab. It must be noted, however that eastern Haryana districts of Karnal, Panipat, Kurkshetra, Yamuna Nagar, Ambala and Kaithal, the cropping pattern is similar to what currently obtains in Punjab. The diversity at macro level in Haryana is a reflection of cropping patterns in Western and Southern districts.



Source : Directorate of Economic and Statistics, Gol.

- 7.6 The increasing concentration of acreage under Wheat and Paddy in the wake of Green Revolution and its impact on soil health, water table, and ecology was recognized quite early. The Government of India and State Govts set up a number of expert committees to recommend measures for promoting diversification of crops in the North West region. As early as 1986, the Government of Punjab set up a committee under Professor S.S. Johl on diversification of Punjab agriculture. The Committee recommended that at least 20% area under Paddy should be diverted to other crops. Another committee headed by Professor S.S. Johl in the year 2002 recommended that at least one million hectare under Paddy and Wheat should be shifted to maize, oil seeds and pulses. A monograph by Ashok Gulati, Ranjna Ray and Siraj Hussain "Getting Punjab Agriculture Back on High Growth Path: Sources, Drivers and Policy lessons" was brought out by ICRIER in July, 2017. The authors recommended that Government should make investment in Maize processing facilities to promote its usability in foods, fodder, poultry feed and industrial applications. The study also recommended bringing 10% of the gross cropped area in Punjab under fruits and vegetables.
- 7.7 The Government of Punjab has taken a number of steps to promote crop diversification. Punjab Agro Industrial Corporation (PAIC) set up in 1966 and Punjab Foodgrains Corporation (PAFC) set up in the year 2002-03, have been working with farmers to promote diversified cropping pattern by providing seeds, other inputs and extension services in a number of commodities. Corporates such as Pepsi foods, Hindustan Lever Ltd., Nijjer Agro Foods Ltd, Nestle and other companies were facilitated to get into contractual arrangements with farmers. Tomatoes, Potatoes, Chilies, Basmati rice were taken up under contractual arrangement. Even some banks, most notably ICICI Bank have tried to promote contract farming arrangements to support crop diversification to support enhanced incomes to the farmers. The Government of Punjab also enacted Contract Farming Act in 2013 to promote contract farming allowing private players to provide inputs and extension services to farmers and procure their produce directly for food processing industry. The issues besetting various models of contract farming as delayed payment, rejection of produce on quality considerations, lack of dispute settlement and contract enforcement mechanisms, in Punjab have been well documented (Contract Farming for Agricultural Development and Diversification in Punjab: Problems and Prospects, by Shri Sukhpal Singh, Indian Institute of Management, Ahmedabad) published in the journal of Punjab Studies, 2005). On account of these problems besetting contract farming, diversification of cropping pattern that was expected has not materialized.
- 7.8 Crop diversification has also been recommended by Expert Committees set up by Haryana. The Working Group on Productivity Enhancement of Crops in Haryana headed by Dr. P. L. Gautam submitted its report's to Haryana

Kisan Aayog in 2013. The working group strongly recommended promotion of other crops namely maize, gaur, pulses and oil seeds in place of Paddy. The report suggests a number of cropping patterns for the agro climatic zones of Haryana. It indicated that hybrid maize, soybean, vegetables, agro-horticulture and agro-forestry could be promoted in some of the paddy growing areas. For Zone-III, comprising districts of Bhiwani, Jajjar, Gurugram, Rewari, Mewat and Mahendergarh, it is recommended complete elimination of paddy.

7.9 The recommendations of the various expert committees and number of schemes promoted by Govt. of India and the states for crop diversification in the North West have not been very successful. Increased acreage under oil seeds and cotton in Haryana has largely come about at the expense of pulses and coarse cereals. This increasing concentration of Paddy - Wheat crop cycle is largely attributed by economists and researchers to assured returns to farmers on account of minimum support prices (MSP) backed by procurement of rice and wheat by the government. Though the Government of India announces MSP for 24 crops, procurement is confined to Paddy and Wheat and some decentralized procurement of cotton and groundnut in a few states. Another factor that contributes to increasing Paddy and Wheat acreage is the stability

in production of these two crops as they are not very susceptible to pests and diseases. Almost complete absence of assured markets for crops which could compete with Paddy like Maize, Kharif pulses, oilseeds, coarse cereals and minor millets leaves farmers with no option but to continue with Paddy and Wheat cycle in spite of its adverse impact on soil, water table and environment in Punjab and Haryana.

7.10 Professor H.S. Shergill of Punjab University, Chandigarh indicated a number of reasons why Paddy and Wheat cropping cycle still continues to remain dominant in Punjab in spite of all efforts at diversification of cropping pattern. He suggested that diversified agriculture was incompatible with commercial farming, something which is happening on a large scale in Punjab. In his opinion Paddy and Wheat combination was the only combination which can sustain current levels of farm income; stability of Paddy and Wheat yields was unmatched in other cropping systems, strong domestic demand and good export prospect; low cost of capital infrastructure for wheat and paddy cultivation, paddy and wheat fully compatible for double cropping and machine use and most suitable for withdrawal of labour from agriculture. He was of the view that there was no alternative to Paddy Wheat cycle even in the long run and any reduction in area under Paddy would have to be gradual and acceptable to the farmers. (Wheat and Paddy Cultivation and the

Question of Optimal Cropping Pattern for Punjab; Journal of Punjab Studies, 2005).

7.11 The Committee in his visit to Punjab and Haryana discussed with the farmers the issue of moving away from Paddy cultivation in elicited their views on diversification to other crops. There was unanimous view that they would take to cultivation of maize and other crops in place of Paddy if they were assured that the maize they produce would be procured. They also suggested that in view of the variability in maize production compared to Paddy, a mechanism to suitably compensate them for the losses they would incur if they shifted to maize cultivation needs to be put in place. Farmers also demanded development of machinery suitable for cultivation of other crops as agricultural labour was very scarce and very expensive.

7.12 In view of the stable income from Paddy and Wheat cultivation and other factors that promoted Paddy, Wheat cropping cycle, it is necessary to identify crops that could compete with Paddy, Wheat cropping cycle and provide equal remunerative and assured prices to the farmers. Various studies and expert committees suggest Maize as a possible replacement for Paddy in Punjab and Haryana. The Commission on Agricultural Costs and Prices (CACP) in its Pricing Policy for Khariff crops regarding season 2018-19 has also recommended "Promotion of Maize as a replacement for Paddy." Farmers would need assured market for Maize they produce for which

procurement arrangements have to be put in place which are currently non-existing. Alternative uses of Maize including Ethanol will have to be promoted for investments to come in to this sector for utilization of maize especially in Punjab. In Haryana part of Maize focus on oilseeds could be sharpened to nudge farmers away from Paddy cultivation. The Government of India could also think of providing subsidies for crops based on area approach. For example, if Maize is to be promoted in Punjab, extension services, subsidized inputs and public procurement could be confined only to Maize in identified districts. This may seem a harsh step at first but could be only solution in the long run to breaking Paddy, Wheat cropping cycle in Punjab and Haryana.

7.13 The analysis indicates that there are a number of paddy varieties of a shorter duration which allow a larger window between harvesting of paddy and sowing of wheat and other crops. The acreage under long duration varieties has continuously increased from 26.7% in 2012 to 73.9% in 2018. The longer duration varieties are grown in those districts which also have a higher incidence of residue burning. Many farmers had indicated that their choice of varieties was also influenced by the preference of the Rice Millers for particular varieties and the price that Millers were willing to offer for those varieties which were outside the scope of the MSP. This is an issue that needs further examination and a solution that should be acceptable to the farmers should be worked out.

CHAPTER - VIII

OBSERVATIONS FROM THE FIELD

- 8.1 The analysis in the previous chapter shows the impact of the Scheme on “Promotion of Agricultural Mechanisation for in-situ Management of Crop Residue” in controlling burning of Paddy Straw in October - December, 2019 period. Happy Seeder and other farm implements which could promote in-situ absorption of Paddy straw have been in the market for more than 7-8 years. Punjab Agricultural University, Ludhiana and a few machinery manufacturers in Punjab and Haryana played a major role in development of these machineries and its adoption by farmers. Even before this scheme was launched in April, 2018 Happy Seeders were used in a few districts of Punjab viz., Patiala and Ludhiana. The new scheme succeeded in taking the Happy Seeders and associated machineries to all parts of the two States. The message that incorporation of Paddy straw in the soil is the most effective and profitable strategy has travelled across Punjab and Haryana.
- 8.2 The wheat acreage sown through Happy Seeder was 502563 hectares which is approx. 8.5% of the total wheat sown in the 2018 Rabi season as many farmers took to this technology for the first time. Therefore, they used Happy Seeder on some parts of their land and sowed the major part of their holding following traditional methods, which also involved burning of paddy straw. Farmers were apprehensive of the new technology to begin with. The Committee visited Punjab and Haryana again in the first week of March i.e 22-23 March, 2019 to get first hand feedback from farmers who had used Happy Seeder machineries for the first time. Their experiences and their concerns are enumerated in the paragraphs below:-
- 8.2.1 **Use of Happy Seeder in Heavy soils:** In few villages in Sirsa district of Haryana, farmers pointed out that the heavy soil in their area restricts percolation of water. Farmers who irrigated their wheat crop found that when it rained within a day or two of application of irrigation, water stood in the field and damaged the crop. This year the monsoon was good and there were frequent winter rains also. The water percolates slowly in heavy soil, and Paddy straw mulch further restricted percolation, damaging the crop.
- 8.2.2 The Committee raised this issue with the faculty of Punjab Agricultural University, Ludhiana who are closely associated with the scheme. They indicated that this problem had occurred in a few patches in Punjab as well. In their opinion this problem could be easily tackled by controlled watering and irrigating the field only after taking in to account Met predictions on rains. They indicated that in Heavy Soils, standing

paddy stubble could promote capillary action, facilitating water percolation. They suggested that in heavy soils, it may be desirable not to use Cutter or Mulcher before sowing wheat through Happy Seeder. PAU faculty indicated that suitable advisories would be issued for 2019 season.

- 8.2.3 Yellowing of Wheat Crop :** In a few places in Punjab, the committee had first visited Punjab and Haryana in December, 2018. The team also came across complaints from farmers that when they had used a cutter or a mulcher on the paddy straw and then used Happy Seeder for sowing wheat, they found that in certain patches in the field the wheat plant yellowed around 3rd week of sowing. Professor Jaswinder Singh from Punjab Agricultural University, Patiala who had accompanied the team explained to the farmers that when the bacteria start decomposing paddy mulch, they require energy which they take from soil, temporarily starving the wheat plants of nutrients. This could lead to yellowing of crop in a few patches. He informed the farmers that once the mulch is decomposed the wheat crop would regain its colour as more nutrients through decomposed straw become available. He also suggested to the farmers that they could also apply a dose of fertilizer, preferably in liquid form, if they wanted to arrest this problem in the beginning itself.

The Committee suggested to the Govt. of Punjab and Haryana officials that advisories to farmers to tackle concerns raised by them should be immediately broadcasted through print and electronic media, including messages on the mobile phones. In the teams' second visit to Punjab and Haryana in March, 2019 this problem was not mentioned as the crops had recovered their colour in a few weeks.





- 8.2.4 The Right Timing for Irrigation:** Farmers irrigate wheat crop between 21st to 25th day of the sowing. A few farmers reported that some wheat plants got damaged after first irrigation. The PAU experts suggested that for wheat which is sown through Happy Seeder after using a shlasher or mulcher, it would be advisable to give first irrigation after 30 days. This is for two reasons. The first is that with the mulch on the top of the soil, moisture is retained and irrigation can be delayed by 10 days. Farmers need to give only 2 irrigation instead of 3 over the crop cycle, thereby saving water. Secondly, when the crop is irrigated at around 21st day, the mulch rises with the water, and when the mulch settles down after irrigation water has percolated down the wheat plants which have not fully come out of the mulch layer could get destroyed,. To avoid this problem their

suggestion was that the first irrigation should be given after 30 to 35 days only when the wheat crop has fully come out of the layer of mulch on the ground.

- 8.2.5 Gap between paddy harvesting and wheat sowing and the issue of weeds of Paddy:** Farmers do not spray paddy crop at least 30-35 days before harvesting as it could lead to pesticide residue in the grain. These weeds remain on the field and could affect wheat crop if wheat is sown immediately after harvesting of paddy. PAU experts suggested that there should be a gap of 10 to 15 days between harvesting of paddy and sowing of wheat. They also suggested that farmers could spray pesticides after harvesting of paddy so that these weeds do not affect the wheat crop.

- 8.2.6 Price of Machinery:** In both the states, the major share of machinery was supplied by the manufacturer located in the Punjab. There was a common refrain from both Punjab and Haryana farmers that machine manufacturers had increased the prices of the machinery and the major part of the subsidy was creamed off by the manufacturers. Many farmers complained that for super SMS, the manufacturers were charging Rs.1.25 lakhs while one could get a super SMS through a local manufacturer at Rs. 60,000 to Rs. 70,000. Farmers also complained that the prices of Happy Seeder, the main equipment for in-situ management, varied from 137760 to 176400. The officials accompanying the Committee explained that the vendors who were empanelled had to conform

to the standards prescribed for different components of the machinery. The maximum price range is for advance machines of 10 rows having depth wheel, press wheel, boron steel shovels. It also includes GST @12% and the cost of transportation from Punjab to Haryana, UP and NCT of Delhi. In the pre-GST era there was no VAT or other taxes on the agricultural machines in the States of Punjab & Haryana. The local manufacturers could provide an equipment at a much lower rate if they use components which were not standardised. On the issue of price variation of Happy Seeder of different manufacturers, it was explained to the farmers that many of the bigger companies have used components of higher standards than those prescribed. These companies have also set up after sale service force which promptly attends to the complaints of the farmers. It was again reiterated that the farmers should buy machinery from the empanelled vendors only as they would be responsible for ensuring proper after sales service. Machinery of the empanelled vendors is tested by the Farm Machinery Testing and Training Centres set up by the government. Only then vendors are allowed to sell their machinery to the farmers. In fact, in Haryana, the team was informed by Beri Udyog Limited that they had only sold 200 Happy Seeders in 2018. During field operations they encountered some problems. After sowing season was over, they have recalled all these Happy Seeders and changed certain components at their own expense and gave the Happy Seeder back to the farmers.

8.2.7

Innovations and improvements in machinery for in-situ Paddy straw management: The Happy Seeder was invented by the Punjab Agricultural University, Ludhiana 10 years ago. The university has been using Happy Seeders for sowing wheat on its own farms. It also worked with the farmers to promote adoption of Happy Seeder for sowing wheat. Even in 2017 around 660 happy seeders were in use in Punjab. The new central sector scheme on “Promotion of Agricultural Mechanisation for in-situ Management of Crop Residue” has given a major boost to manufacturing of Happy Seeders and other related machineries by private companies. Many of these are small scale manufacturers. The Committee was happy to note that major modifications and innovations are being carried out on the Happy Seeder to make it more effective and acceptable to the farmers. One such example is Happy Seeder with rotavator blades in front, which has been manufactured by Dashmesh Mechanical Works, Malerkotla. This machine has also been successfully tested by the Testing Centre of Haryana Agriculture University, Hisar. Similarly, the committee also came across a new mulcher and Happy Seeder machine. These innovations and modifications would get further support once demand for these equipments is fully established.

8.2.8

Rental charges of Happy Seeder: As mentioned earlier Happy Seeder were in use in Punjab during sowing of wheat in 2017

also. 660 Happy Seeders, owned by individual farmers were working in Ludhiana, Patiala and few other districts. A team of Ministry of Rural Development, Government of India had visited Punjab in November, 2017 to make an on the spot assessment of Paddy Straw burning and possible solutions to this problem. The team came across farmers who were using Happy Seeders to sow wheat on their farms and also leasing out this machinery to other farmers. In 2017 the rental charge per acre was around Rs. 1800 to Rs. 2200 per acre (including tractor and Happy Seeder). The Committee in its visit to Punjab and Haryana in November, 2018 found that with a large number of Happy Seeders and other machineries, the rental charges had fallen significantly to Rs. 1000- 1200 per acre. In cases where Common Interest Groups had taken happy seeders, the rental charges had come down to Rs. 700-800 per acre, making it possible for small and marginal farmers also to use Happy Seeders for sowing wheat. The expenses on sowing through Happy Seeder have come down by roughly 1/3rd of the total cost incurred when the Paddy Straw was burnt and the field prepared in a traditional manner for sowing of wheat.

8.3

The Committee's interaction with farmers brought out some of the concerns of the farmers which are listed above. Two things that clearly stand out and require timely response from machinery manufacturer and Agricultural Universities and Research Institutions are issues related to after sales service for the CRM machinery, especially Happy Seeders, and the agronomic practices that would have to be modified in view of the local and farm level conditions. Punjab Agricultural University, Ludhiana and Haryana Agricultural University, Hisar have been playing a very pro-active role in providing timely advisories to the farmers. Departments of Agriculture in both the States and ICAR institutions especially, KVKs have been equally proactive. These institutions should be strongly supported to further increase their outreach and hand hold farmers in the next two years to address specific problems that might crop up with adoption of these new technologies.

CHAPTER - IX

USES OF CROP RESIDUE

- 9.1 In Punjab, presently about 4.30 million tonnes of Paddy is being utilized by various stake holders without burning the same in the fields as per details given in Table-17

Table-17

Sr. No.	Activity	Consumption of paddy straw million ton per year
1.	Paddy straw being used in 7 Biomass based projects of capacity 62.5 MW	1.0
2	Paddy straw being used in paper / Cardboard mills	0.10
3	Paddy residue from 5 lacs hectare of basmati being utilized as animal fodder and other usages.	2.70
4	Paddy residue being managed through different available straw management system including machinery / equipments.	6.41 *
TOTAL		10.21 (50.6% of total paddy straw generation)

*Out of this 2.89 MT partially burnt or taken out of fields.

- 9.1.1 The details of the Biomass plants utilizing this paddy for the production of power are given below:-

(A) Biomass Power Projects in operation

- (i) **Rankine Cycle (Bioler& Turbine)** - 7 Projects, 63 MW capacity at Channu & Gulabewala (Muktsar), Gaddadhob (Ferozepur), Khokhar Khurd (Mansa), Birpind (Jalandhar), Binjon (Hoshiarpur), Ghanaur (Patiala).
- (ii) **Otto Cycle (Bio-methanation)**
1 Project, 4 MW capacity at Binjon (Hoshiarpur)

(B) Co-generation Projects in Industry- 55 Projects, 436 MW capacity

(C) Bio-energy Projects in Pipeline:- (Biomass, Bio-ethanol & Bio-CNG)

- (i) Sukhbir Agro Energy Ltd. - Biomass rice straw based 2 Projects of 30 MW capacity in District Faridkot & Ferozepur - work commenced.
- (ii) Verbio - A 30 MT Bio-CNG Paddy Plant in District Sangrur - work commenced.
- (iii) HPCL (2G Ethanol Bio-refinery)
100 KL per day production of Food Grade Ethanol based on Biofuel in Tehsil Talwandi

Saboo, District Bathinda - work commenced.

(iv) Neway Renewable Energy (Bio-coal plant based on Paddy) - 75000 ton Bio coal per annum in District Bathinda - work commenced.

(v) Indian Oil Corporation Limited and Shiv Om Dayal Energy Private Limited, Mahindra Waste to Energy Solutions Pvt. Ltd-Projects under consideration.

9.1.2 The Department of Agriculture & Farmers Welfare, Punjab has provided subsidy to Farmers / Farmer Groups on purchase of 188 Balers & 171 Rakes for Collection & Removal of Paddy Straw, for ex-situ management of paddy straw by way of Industrial usage.

9.1.3 The State of Haryana has notified Bio Energy Policy and has made agreement with Indian Oil Corporation for setting up of 14 Compressed Bio Gas (CBG) plants. The Ethanol plants of IOCL at Bohali, Panipat has agreed to purchase the paddy straw at remunerative price from the farmers.

9.1.4 In order to explore ex-situ solution for management of the crop residue burning, the Department of Agriculture, Cooperation & Farmers Welfare has constituted a committee under the chairmanship of Dr. K. Alagusundaram, Deputy Director General (Engg.), Indian Council of Agricultural Research (ICAR) having representation from Ministry of New and Renewable Energy (MNRE), Ministry of Environment Forest and Climate Change (MoEF&CC), Ministry of

Power (MoP), Ministry of Petroleum and Natural Gas (MoP&NG), Central Pollution Control Board (CPCB) etc. The committee has made the following recommendations towards ex-situ solutions of crop residue management:

(i) Straw collection in the field is a major bottleneck in whole straw management chain, hence, the use of balers may be encouraged for collection of straw from the field. It was realized that the time for collection of straw is very limited and man power for collection of straw is also scarce during this period, hence, collection through baler seems to be most feasible and economical option.

(ii) It was realized that there is requirement of considerable area for the safe storage of bales for their utilization during off period. Hence the land available in the village may be undertaken on lease or Panchayat land may be made available for decentralized storage of bales. Transportation of the bales up to the safe storage place may be encouraged.

(iii) Production of briquettes /pellets is also feasible option from crop residues/paddy straw. Paddy straw mixed with other straw (pigeon pea straw, soybean straw or any other binding material) may be used for production of briquettes /pellets which may be utilized for industrial purposes for production of heat or elect-

ricity generation. However, feasibility of production of pellet/briquettes from 100% paddy straw substrates needs to be confirmed through experimentation as presently available machines may require some modification for utilization of paddy straw. Reduction in production capacity, maintenance issues of machinery with the use of paddy straw and requirement of additional equipment such as flash dryer to produce the pellets/briquettes may be compensated.

- (iv) Production of power from pelletized/ briquetted straw may be implemented in the decentralised power generation mode as it seems to be economical in this manner. The smaller size (4-10 MW) biomass based power plants may be encouraged. The government financial support for biomass based power generation may boost the installation of the power plants.
- (v) The option of paddy straw utilization for bio gas production (3-20m³ biogas per day) may be tried in the rural areas.
- (vi) Production of the bio-CNG using paddy straw in big set ups may be encouraged.
- (vii) The utilization of agro residue based bio-fuel for power generation will not only discourage in-field crop residue burning abating air pollution, but will also reduce carbon footprint of coal based power plants. Torrified/non-

torrified biomass pellet may be blended with coal (5-10% as per the advisory of the Central Electricity Authority) in the thermal power plant. However, easy availability of the pellets on regular basis at optimum/stable price may be encouraged.

- (viii) The paddy straw which has cellulosic and lignocellulosic content, can be converted to ethanol using second generation (2G) technologies. The paddy straw may also be utilized for production of ethanol in big set ups. Government of India has allowed procurement of ethanol produced from other non-food feedstock besides molasses, like cellulosic and lignocelluloses materials including petrochemical route, subject to meeting the relevant BIS standards. Globally, 2G ethanol industry is driven by incentives as the technology is yet to be proven at commercial scale and the ethanol so produced is more environment friendly.
- (ix) The small scale parali-char/bio-char production system from paddy straw may be encouraged for its production and utilization as soil amendments on trial basis for proving its economics and acceptability.

9.2

The ex-situ utilization of paddy straw in industrial applications and power generation has been considered and even promoted by the government by providing various incentives, especially

for power generation. The committee however is of the view that the best and most environmentally sustainable use of paddy straw is its incorporation in the soil itself. This can be easily achieved by supporting farmers to buy the CRM machinery and running a sustained IEC campaign for proper utilization of the machinery. Ex-situ utilization of paddy straw would be damage soil health in the long run as it would remove green carbon potash, phosphorous and other minerals present in the paddy straw. Research over a 9 year period conducted by Punjab Agricultural University, Ludhiana shows that,

farms that incorporated paddy/wheat straw in the soil improved their carbon content from 0.33% in 2009 to 0.746% in 2018 (**Details are in Annexure XVI**). In view of such clear research findings, the committee recommends that industrial applications and power generation for paddy straw should be discouraged. Ex-situ management is more expensive than in-situ management of paddy straw and should not be encouraged through subsidy and incentives. The government support should only be confined to those techniques that promote incorporation of paddy straw in the soil.

CHAPTER - X

SUMMARY & RECOMMENDATIONS

- 10.1 Haryana and Punjab together produced 28.10 million tonnes of paddy straw (2018 estimates) out of which 11.30 million tonnes i.e. 40.21% of the paddy straw was burnt in the fields. 59.79% was managed through incorporation in the soil and other measures. Haryana accounted for 11.85% of the straw while Punjab accounted for 88.15% of the straw burnt in these two States.
- 10.2 The government of India and state governments of Punjab and Haryana have taken a number of steps to control burning of paddy straw. Agricultural universities and KVKs had also played a major role in persuading farmers to manage paddy straw without resorting to burning. As a result of these efforts, there was a significant reduction in fire incidents in 2017 over incidents of fire in 2016. With the inception of the new schemes on Promotion of Agricultural Mechanization for in-situ Management of Crop Residue in April, 2018, there was a further reduction in incidents of burning. This reduction was very sharp in Haryana and moderate in Punjab. Large scale burning is confined to Fatehabad, Sirsa, Kaithal, Karnal and Kurukshetra in Haryana. In Punjab, Sangrur, Bhatinda, Firozpur, Muktsar, Mansa and Patiala witnessed high incidence of burning, though there was a substantial reduction in incidents of burning in some of these districts in 2018, in comparison to 2017.
- 10.3 The physical target for providing machinery in 2018-19 for individual farmers was over achieved in Punjab and was 99% in case of Haryana. A major issue however, was the delayed supply of machinery to farmers, especially in Punjab where the final date for supply of machinery was extended to 15.11.2018, a date by which time wheat sowing was almost completed in many districts.
- 10.4 From interactions with the farmers, it clearly emerged that, had machineries been provided by end of September/beginning October, sowing through Happy Seeder would have been on a bigger scale. Since 2018 was the first year of the roll out of the schemes, such delays could be expected. The Committee strongly recommends that CRM machineries to be provided in 2019-20 should be positioned in the field by 30th September. The machinery manufacturers have already ramped up their production capabilities and firm order from the State governments well in time would ensure that machinery is in place by 30th September, 2019.
- 10.5 Many farmers took to the use of CRM machinery for sowing of wheat for the first time. Therefore, they were naturally apprehensive of the production of wheat in the new system of cultivation. They allocated a part of their wheat acreage for sowing through

happy seeder and in the remaining parts they had resorted to crop burning and conventional sowing. In the interaction with the farmers who had used Happy Seeder for sowing wheat for the first time, the farmers expressed their happiness with the growth of the wheat crop sown through Happy Seeder and indicated that from the next year onwards, i.e. rabi 2019, they would sow wheat through Happy Seeder only, if machinery was available to them on time. In this context, it is important to ensure that CRM machinery is available to the farmers for the entire sowing period. This will also reduce over capitalization of the sector. The Committee also noted with concern that deployment of CRM machinery in Uttar Pradesh was extremely lop-sided. In Uttar Pradesh largely rotavators and some zero till drills were distributed. The major expenditure was on rotavator only. The rotavator is useful for sowing of potato and is not really relevant for sowing of wheat.

10.6 The governments of Punjab and Haryana have been working with the farmers, agricultural universities and ICAR institutions to prevent burning of crop residue and promote CRM machinery. With the inception of the new scheme in April, 2018, these efforts have been significantly expanded. The IEC campaigns were run extensively. Many non-governmental organizations including industrial associations like CII, Birla Foundation and others have also joined hands to take forward the

message of incorporating paddy straw in the field. In addition, Haryana imposed fines on some of the farmers to send a strong message that crop residue burning would not be tolerated in the State. There is enough scientific evidence now to indicate that conservative farming through Happy Seeder and other CRM machines is not only more cost effective option but also improves soil health, augmenting farmers' incomes in the medium term. The Committee recommends that IEC campaign through various media be continued during August to October, 2019 period. There is a need to weak agronomic practices for crops sown through CRM machinery. The research institutions and extension agencies would need to issue timely advisories and hand hold farmers who may encounter specific and localized problems.

10.7 There are a number of paddy varieties of a shorter duration which allow a larger window between harvesting of paddy and sowing of wheat and other crops. The acreage under short duration varieties has continuously increased from 26.7% in 2012 to 73.9% in 2018. The longer duration varieties are grown in those districts which also have a higher incidence of residue burning. Many farmers had indicated that their choice of varieties was also influenced by the preference of the Rice Millers for particular varieties and the price that Millers were willing to offer for those varieties which were outside the scope of the MSP. This is an issue that needs further examination

and a solution that is acceptable to the farmers should be worked out.

10.8 The Committee's interaction with farmers brought out many concerns of the farmers. Two things that clearly stand out and require timely response from machinery manufacturers and Agricultural Universities and Research Institutions are the issues related to after sales service for the CRM machinery, especially Happy Seeders, and the agronomic practices that would have to be modified in view of the local and farm level conditions. Punjab Agricultural University, Ludhiana and Haryana Agricultural University, Hisar have been playing a very pro-active role in providing timely advisories to the farmers. Departments of Agriculture in both the States and ICAR institutions especially, KVKs have been equally pro-active. These institutions should be strongly supported to further increase their outreach and hand hold farmers in the next two years to address specific problems that might crop in adoption of these new technologies.

10.9 The diversification of crops away from paddy wheat, cropping cycle has been on the agenda of the government, both Central and state governments for a long time. Horticulture, vegetables and cultivation of maize have been recommended for adoption in Punjab and Haryana by a number of Committees set up in the past. Unfortunately, these efforts have not been very successful. The paddy-wheat combination

accounting for 92% of the Gross Cropped Area in Punjab. The Maize which is considered as a alternative to paddy in Punjab and Haryana would be acceptable to the farmers only if production and procurement uncertainties of maize are resolved to their satisfaction. Use of maize in industrial applications mainly of ethanol and other products will have to be encouraged before maize as a alternative to paddy can be adopted in the medium to long term.

10.10 The ex-situ utilization of paddy straw in industrial applications and power generation has been considered and even promoted by the government by providing various incentives, especially for power generation. The Committee, however is of the view that the best and most environmentally sustainable use of paddy straw is its incorporation in the soil itself. This can be easily achieved by supporting farmers to buy the CRM machinery and running a sustained IEC campaign for proper utilization of the machinery. Ex-situ utilization of paddy straw would damage soil health in the long run as it would remove green carbon, potash, phosphorous and other nutrients present in the paddy straw. Ex-situ management could be considered if economically viable which bring technologies back bio fertilizers to the field. The government support should only be confined to those techniques that promote incorporation of paddy straw in the soil.

No.13-41/2016- M&T (I&P)
 Government of India
 Ministry of Agriculture & Farmers Welfare
 (Department of Agriculture, Cooperation & Farmers Welfare)
 Room No. 238, Krishi Bhawan,
 Dr. Rajendra Prasad Road,
 New Delhi -110001

Dated: 19th November 2018

OFFICE ORDER

In pursuance to the order dated 12.11.2018 passed by the Hon'ble National Green Tribunal (NGT) in OA No. 666/2018 (Earlier OA No. 451/2018) of Smt. Ganga Lalwani Vs. Union of India and Others, a meeting was convened by the Secretary DAC&FW with the Chief Secretaries of Punjab, Haryana and Uttar Pradesh States on 14.11.2018 at Krishi Bhawan, New Delhi. Apart from the other recommendation, the meeting held on 14.11.2018 also recommended that a committee may be constituted to look into the issues of crop residue burning.

2. Accordingly, it has been decided to constitute a committee as under:

- (i) Shri Nagesh Singh, Head Poverty, SDGS, NIRD, MoRD- Chairman
- (ii) DDG (Engg)-ICAR - member
- (iii) Additional Chief Secretary (Agriculture)/ Principal Secretary (Agriculture) of the Government of Punjab, Haryana & Uttar Pradesh - Members
- (iv) Joint Secretary(M&T), DAC&FW—Convener

3. The Terms of Reference (ToRs) of the committee will be as under:

- (i) Assessment of the numbers of machinery distributed in States of Punjab, Haryana and Uttar Pradesh under the Central Sector Scheme of in-situ crop residue management
- (ii) Assessment and impact of the machinery use by the farmers.
- (iii) Assessment of the benefits accrued to the farmers.
- (iv) Recommending the area specific varieties of paddy crops for the areas where crop burning is higher
- (v) Suggesting alternative more remunerative and advantageous industrial use of crop residue in respective States.
- (vi) Recommending other inputs, for making long term policy for preventing crop residue burning.

4. The Chairman of the committee may co-opt any other additional experts for their specific inputs.

5. The Committee shall endeavor to submit its report as expeditiously as possible, within 3 months.

This is issued with the approval of competent authority of this Department.

(Ashwani Kumar)
 Joint Secretary to the Government of India
 Telefax No. 23382937
 Email: ashwani.hub@nic.in

Distribution:

1. Dr. Nagesh Singh, Head, Poverty, SDGS, NIRD, MoRD
2. The Deputy Director General (Agricultural Engineering), Indian Council of Agricultural Research (ICAR), Krishi Anusandhan Bhavan –II, Pusa, New Delhi – 110012
3. The Additional Chief Secretary (Development), Government of Punjab, Room No. 327, 3rd Floor, Punjab Civil Sectt.-2, Chandigarh – 160022.
4. The Principal Secretary, Agriculture and Farmers Welfare Department, Government of Haryana, New Civil Secretariat, 4th Floor, Sector 17, Chandigarh – 160017 (Haryana)
5. The Principal Secretary (Agriculture), Government of Uttar Pradesh, U.P. Secretariat Main Building, Lucknow 226001 (Uttar Pradesh)

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Minutes of the meeting of the Committee constituted in pursuance to the Order passed by Hon'ble National Green Tribunal, Principal Bench, New Delhi in OA No. 666/2018

The 1st meeting of the committee constituted in pursuance to the Order dated 15.11.2018 passed by Hon'ble National Green Tribunal, Principal Bench, New Delhi in OA No. 666/2018, was held at 12.00 PM at Haryana New Civil Secretariat, Sector 17, Chandigarh under the chairmanship of Dr. Nagesh Singh. The list of participants is annexed. There was no participation from the Government of Uttar Pradesh and the ICAR.

2. At the outset, Chairman welcomed all the members of the committee and briefed them about the task given to the Committee. He advised that the assessment needs to be done by all the three States as to how many machines have actually reached the farmers well before the paddy harvesting season and the machines that have been actually used by the farmers alongwith the area covered by these machines. A comprehensive statement on area covered by in situ management of crop residue for 2017-18 and 2018-19 would be required.

3. The Secretary (Agriculture), Government of Punjab informed that 27500 machines have been supplied in the State and its usage and area covered is being estimated. There are 8000 villages in 8 districts of South-West Punjab where more residue burning events were noticed. Un-expected rainfall on 28th Sept 2018 was the major reason for this. However, the Government of Punjab have appointed nodal officers in these villages who would be interacting with farmers and understand the reasons behind residue burning. They would also ask farmers what is the kind of machinery they would require if they had to stop residue burning. This exercise would be completed in January – February, 2019 and would be the basis for further strategic planning and plan of action.

Happy seeder, cutters and mulchers have been provided to 3250 Cooperative Societies and 1100 farmers groups and this model was found to be successful. The State Government is focusing on crop diversification and campaign is being carried out to discourage the farmers from growing PR 44 variety of paddy. He suggested that a long term action plan needs to be put in place to wean farmers away from paddy cultivation as it is also a water intensive crop and most blocks in Punjab have turned dark or grey zones.

4. The Additional Chief Secretary, Government of Haryana stated that, in the State of Haryana the area under basmati rice has no burning or very limited burning. She highlighted the success of Haryana in significantly controlling residue burning which was lower by about 40% in 2018 compared to last year. Apart from the in-situ management of paddy straw, she emphasized upon exploring different remunerative practices for paddy straw disposal which make economic sense to the farmers. As it involves a cultural shift, the communication needs to be established with the farmers in a strategic and more professional manner. It would take sustained efforts over next two years to eliminate residue burning and she was hopeful that this could be achieved.

5. The Committee also visited Patiala and Sangrur districts in Punjab and Karnal district in the State of Haryana. During the visit, the Custom Hiring Centres and demonstration

plots were inspected. The area managed by using different machines has also been inspected. Discussions were held with the district level agricultural officers, farmers groups and industry. After detailed discussions on different issues and based on the experience of the implementation of the scheme, the following points emerged for further action.:-

- (1) As the detailed report is required to be submitted to the Hon'ble National Green Tribunal on or before 30th of April 2019. All the three States should carry out the assessment of the machines that have actually reached the farmers, the area covered by these machines and the impact of usage of these machines in reducing the paddy straw burning.
- (2) All the three State Governments should compile reports on district-wise burning incidences as per satellite images, number of incidence after physical verification/spots visits, the actual area burned and the numbers of cases where penalty was imposed and taken to logical conclusion.
- (3) Crop diversification in the State of Punjab and Haryana may be encouraged and the farmers may be motivated to replace PR 44 variety of paddy with other available alternate varieties of shorter duration.
- (4) The equipments and machines have been provided to the Cooperative Societies in the State of Punjab with 80% assistance from the Government, However, it has been noticed that the Cooperative Societies are charging high amount for renting out the machines to the farmers. The State Governments should review the rental charges of the Cooperative Societies and ensure that these are reasonable and affordable to the farmers.
- (5) Though the in-situ management of paddy straw is found to be most economic, the State Governments should explore other alternative and remunerative methods of paddy straw disposal which makes economic sense to the farmers and such practices may be promoted in the regions where these are feasible. The funds under Sub-Mission on Agricultural Mechanization may be utilized for providing machines and equipments to the entrepreneurs/farmers.
- (6) As the adoption of technology involves cultural shift. Therefore, the studies should be conducted on behavioral changes of the farmers and accordingly the Information, Education & Communication (IEC) strategies should be planned for the next year. The IEC action plan for the period from January 2019 to March 2019 should be prepared and implemented focusing on the areas where burning events were more.
- (7) Some of the farmers/owners of the Custom Hiring Centres have complained about the defects and breakdowns in the machines supplied by some of the manufacturers. The suppliers of such machines which failed to deliver the desired output may be identified and action against such manufactures/ suppliers as appropriate should be taken by the State Governments. This is important to allay farmers' apprehensions as sub-standard and cheaper machines which breakdown frequently would affect the credibility of the programme.
- (8) Some farmers complained that the wheat plants were yellowing in certain patches and were apprehensive that crop yield would suffer. KVK scientists who accompanied the team explained that in the initial days when paddy straw starts decomposing microbes require more nitrogen and therefore the nutrient supply to the growing wheat crop declines. They indicated that fertilizer dosages need to be given at specific intervals to address this issue. Punjab and Haryana Govt. official intimated that they would immediately run an EC campaign through print, electronic and social media to spread awareness among farmers on this issue.

- (9) Development of mobile app-based aggregator platform to facilitate hiring of farm machinery from the Custom Hiring Centres to ensure better utilization of the resources of such centres is essential. The Services App may connect Custom Hiring Centres (CHC) directly to farmers who need farm machinery on hire. This will facilitate a fair and transparent rental process while focusing on quality, dependability and timely delivery of the services. The State Governments should develop such App for the benefit of small and marginal farmers.
- (10) The committee also suggested that demand for CRM related machinery should be obtained from farmers and made available to the manufacturers by May, 2019 so that machine can be positioned in the field by end September, 2019.

The meeting ended with vote of thanks to the chair.

List of Participants

- 1) Dr. Nagesh Singh, Head & Consultant, Centre for Poverty Studies and Social Registry, NIRD & PR, MoRD, New Delhi.
- 2) Mrs. Navraj Sandhu, Additional Chief Secretary to the Govt. of Haryana, Agriculture & Farmers' Welfare
- 3) Shri Ashwani Kumar, Joint Secretary, DAC&FW, New Delhi
- 4) Shri. K.S. Pannu, *Secretary (Agriculture), Government of Punjab*
- 5) Shri Ajit Balaji Joshi, Director (Agriculture), Government of Haryana
- 6) Shri Arvind Meshram, Deputy Commissioner (M&T), DAC&FW, New Delhi
- 7) Shri R.S.Chahal, Joint Director (Engg.), Government of Haryana
- 8) Shri ManmohanKalia, Joint Director (Engg.), Government of Punjab

The list villages and factories visited by the committee during the visit on 13-15 December 2018

1) Manufacturers Visited:

- (i) Patiala Disc Corporation, Rajpura , District –Patiala (Punjab)
- (ii) New Gurdeep Agriculture Works, Nabha Road, Chaswal (Bhadson), District-Patiala (Punjab)
- (iii) Dasmesh Mechanical Works, Amargarh, District-Sangrur (Punjab)
- (iv) Beri Udyog Pvt. Ltd., District- Karnal (Haryana).

2) Custom Hiring Centres and Farmers Groups:

- (i) Village Kheri Gandyan, Block-Rajpura , District- Patiala-Punjab
- (ii) Mai Bhago Swayam Sahayta Group, Village DaronKalan, District-Patiala (Punjab)
- (iii) Village Dalanpur, Block- Bhunerheri, District-Patiala (Punjab)
- (iv) Village-Allowal, Block-Bhadson, District-Patiala (Punjab)
- (v) Village- Chaswal, Tehsil- Nabha, District-Patiala (Punjab)
- (vi) Village- KallarMajri, Tehsil- Nabha, District-Patiala (Punjab)
- (vii) Singla Cooperative Society, Village –Saaron, District- Sangrur (Punjab)
- (viii) Saaron Multipurpose Cooperative Society, Village- Kanoi District- Sangrur (Punjab)
- (ix) Kunjpura Kisan Welfare Society, Kunjpura, District- Karnal (Haryana)
- (x) Horticulture Farmers Producer Company, Village-Sangoha District- Karnal (Haryana)
- (xi) Shahi Farmers Sewa Samiti, Village-Sangoha District- Karnal (Haryana)
- (xii) Regional Research Centre, HAU, Uchani District-Karnal (Haryana)
- (xiii) Progrowers Farmers Producer Company, Village-Tarawadi District-Karnal (Haryana)

**Minutes of the meeting of the Committee constituted in pursuance to the Order passed
by Hon'ble National Green Tribunal, Principal Bench, New Delhi
in OA No. 666/2018**

The 2nd meeting of the committee constituted in pursuance to the Order dated 15.11.2018 passed by Hon'ble National Green Tribunal, Principal Bench, New Delhi in OA No. 666/2018, was held on 31.01.2019 at 11.00 A Min Krishi Bhawan, New Delhi, under the chairmanship of Dr. Nagesh Singh. The list of participants is annexed. There was no participation from the Government of Uttar Pradesh.

2. At the outset, Chairman welcomed all the participants and briefed them about the task given to the Committee. He also briefed about the 1st meeting of the committee followed by the field visits in the States of Punjab & Haryana where the paddy straw managed by different methods has been witnessed by the committee. Further, he stated that one of the ToRs of the committee is to recommend area specific varieties of crops where crop burning is higher. Accordingly, it becomes important to explore the shorter duration varieties of paddy and the alternative crops that can replace the paddy area without compromising the returns that the farmers are presently getting.

3. The Director of Research and Sr. Rice Breeder cum HoD of PAU Ludhiana made a Power Point presentation on the role of 'Short Duration and Low Biomass Varieties in Paddy Residue Management'. It was informed that the area covered by shorter duration variety has increased from 32.6% in 2012 to 81.9% in 2018 in the State of Punjab. Pusa 44 variety of paddy is of longer duration and is mostly grown in Moga, Ludhiana, Sangrur, Barnala and Sri Muktsar Sahib districts of Punjab. These districts are more vulnerable for paddy straw burning.

4. However, Pusa 44 is preferred by the farmers as it gives 2 quintals per hectare more yield than other available varieties. They further informed that PR 121 variety developed by PAU Ludhiana is of shorter duration (110 days) and its milling recovery is also good when compared with PR 126 variety. This variety is recommended as it would provide larger window for wheat sowing after the harvest of paddy crop. The PAU Ludhiana has also conducted demonstrations and distributed seeds free of cost in these 5 vulnerable districts of Punjab. PAU Ludhiana has also recommended de-notification of Pusa 44 variety along with creating awareness among farmers by way of more number of demonstrations of PR 121 variety and also assuring the seed availability.

5. The representative from National Seeds Corporation (NSC) informed that the NSC is not doing seed production of Pusa 44 variety.

6. Dr. Rajbir Yadav, Principal Scientist, IARI, Pusa, New Delhi informed that the Punjab have large areas where wheat is sown. However, Haryana has very negligible late wheat sown area. Ten days early transplanting of paddy and providing higher MSP to the alternate crops such as maize would be helpful in managing the paddy straw in both the States.

7. On the issue of alternate crops for paddy in the State of Punjab, the Director of Research and Sr. Rice Breeder cum HoD of PAU Ludhiana informed that Maize has less productivity and there is big gap in return when compared with growing of paddy. MSP is declared for Maize but there is hardly any procurement Maize. Growing of Maize can be promoted in the areas/blocks where paddy yield is less than 4 ton/ha. They have also suggested that higher MSP may be provided to Maize.

8. After detailed discussion on the alternate shorter duration of paddy varieties and the alternate crops for the paddy, the committee recommended the following:

- (i) The PAU Ludhiana may provide detailed note on the alternate available options of shorter duration paddy varieties, the work done towards promoting the shorter duration paddy varieties and the pros and cons of the same.
- (ii) The withdrawal of the notification of Pusa 44 variety of paddy may be taken up with the appropriate authorities by the Department of Agriculture, Cooperation and Farmers Welfare.
- (iii) Dr. Rajbir Yadav, Principal Scientist, IARI, Pusa, New Delhi may provide detailed economics of growing of Maize vis-à-vis paddy and also suggest the price band that would be reasonable for promoting the growing of Maize.

The meeting ended with vote of thanks to the chair.

List of Participants

- 1) Dr. Nagesh Singh, Head & Consultant, Centre for Poverty Studies and Social Registry, NIRD, MoRD, New Delhi.
- 2) Shri Ashwani Kumar, Joint Secretary, DAC&FW, New Delhi
- 3) Dr. N.S. Bains, Director of Research, PAU Ludhiana
- 4) Dr. G.S.Mangat, Sr. Rice Breeder cum HoD, Plant Breeding & Genetics, PAU Ludhiana
- 5) Dr. Mangat Ram, Principal Scientist, CCS HAU, Hisar
- 6) Dr. Rajbir Yadav, Principal Scientist, IARI, Pusa, New Delhi
- 7) Dr. P.L.Singh, Principal Scientist, Division of Agricultural Engineering, ICAR
- 8) Shri R.S.Chahal, Joint Director (Engg.), Government of Haryana
- 9) Dr. Baldev Singh, CAO Sangrur, State Deptt. of Agriculture, Government of Punjab
- 10) Shri Kuldeep Singh, Sr. General Manager, National Seeds Corporation, New Delhi
- 11) Dr. M.N. Singh, Deputy Commissioner (Crops), DAC&FW, Krishi Bhawan, New Delhi
- 12) Shri Arvind Meshram, Deputy Commissioner (M&T), DAC&FW, New Delhi

**The list villages/Institutions visited by the committee
during the visit on 22-23 March 2019**

- 1) Northern Region Farm Machinery Training & Testing Institute, Hisar (Haryana)
- 2) National Seed Corporation, Hisar (Haryana)
- 3) Village Karnauli, District-Fatehabad (Haryana)
- 4) Vinayak Agriculture Society, Village –Kotli, District-Sirsa (Haryana)
- 5) Village-Suchan, District-Sirsa (Haryana)
- 6) Village- Mangala, District-Sirsa (Haryana)
- 7) Kisan Self Help Group, Village- Jagram, District - Bathinda (Punjab)
- 8) Village Mahi Nangal, District -Bathinda (Punjab)
- 9) Krishi Vigyan Kendra, District Bathinda (Punjab)
- 10) Village – Daddho, District - Bathinda (Punjab)
- 11) Punjab Agriculture University, Ludhiana (Punjab)

District-wise details of Paddy Straw Management in Haryana State

Annexure-VI

(Area in hectares)

S. No.	District	Total Area under Paddy (Total Straw in MT)	Area under basmati (Straw in MT)	Area under Non-Basmati (Straw in MT)	Total target area to be covered for 100% straw management (10% Basmati Area + 100% Non-basmati area) (Straw in MT)
1.	Karnal	172000 (9,46,000)	86000 (4,73,000)	86000 (4,73,000)	94600 (5,20,300)
2.	Kaithal	165896 (9,12,428)	46913 (2,58,021)	118983 (6,54,406)	123674 (6,80,207)
3.	Jind	132000 (7,26,000)	124000 (6,82,000)	8000 (44000)	20400 (1,12,200)
4.	Kurukshetra	118000 (6,49,000)	44000 (2,42,000)	74000 (4,07,000)	78400 (4,31,200)
5.	Fatehabad	117830 (6,48,065)	53640 (2,95,020)	64190 (3,53,045)	69554 (3,82,547)
6.	Sonipat	95000 (5,22,500)	85000 (4,66,500)	10000 (55,000)	18500 (1,01,750)
7.	Sirsa	72000 (3,96,000)	57600 (3,16,800)	14400 (79,200)	20160 (1,10,880)
8.	Ambala	84000 (4,62,000)	12000 (66000)	72000 (3,96,000)	73200 (4,02,600)
9.	Y/Nagar	71000 (390500)	14600 (80300)	56400 (310200)	57860 (318230)
10.	Panipat	74000 (407000)	63000 (346500)	11000 (60500)	17300 (95150)
11.	Hisar	60000 (33000)	44700 (245850)	15300 (84150)	19770 (108735)
12.	Rohtak	46850 (257675)	44508 (244794)	2343 (12886)	6794 (37367)
13.	Jhajjar	39000 (214500)	36391 (200150)	2609 (14349)	6248 (34364)
14.	Palwal	19000 (104500)	15400 (84700)	3600 (19800)	5140 (28270)
15.	Bhiwani	22450 (123475)	22000 (121000)	450 (2475)	2650 (14575)
16.	Faridabad	9200 (50600)	7360 (40480)	1840 (10120)	2576 (14168)
17.	Panchkula	10448 (57464)	3 (16)	10445 (57447)	10445 (57447)
18.	Mewat	4750 (26125)	4750 (26125)	0	475 (2612)
19.	Gurgaon	4950 (27225)	4900 (26950)	50 (275)	540 (2970)
20.	Rewari	1330 (7315)	30 (165)	1300 (7150)	1303 (7166)
	Total	1319704 (7258372)	766795 (4217373)	552910 (3041005)	629590 (3462742)

The district-wise details of Paddy Straw Management in Punjab State

(Area in hectares)

S.No.	District	Area under Paddy	Area under Basmati	Area under Non-Basmati	Paddy area burned	Paddy Straw Burned (MT)
1	Amritsar	180000	139000	41000	84110	47102
2	Barnala	114000	3000	111000	70990	39754
3	Bathinda	167000	2000	165000	110360	61802
4	Faridkot	116000	27000	90000	89150	49924
5	Fatehgarh Sahib	86000	8000	79000	45930	25721
6	Fazilka	114000	72000	42000	49850	27916
7	Firozpur	186000	12000	174000	160640	89958
8	Gurdaspur	172000	55000	117000	80560	45114
9	Hoshiarpur	75000	6000	69000	20970	11743
10	Jalandhar	173000	5000	168000	94430	52881
11	Kapurthala	118000	5000	113000	50240	28134
12	Ludhiana	259000	14000	245000	128310	71854
13	Mansa	116000	3000	113000	65590	36730
14	Moga	181000	5000	176000	129870	72727
15	Sri Muktsar Sahib	179000	41000	138000	93860	52562
16	Pathankot	28000	1000	27000	4900	2744
17	SBS Nagar	60000	0	60000	12430	6961
18	Patiala	234000	25000	210000	161840	90630
19	Rupnagar	41000	5000	36000	10040	5622
20	Sangrur	287000	25000	262000	185420	103835
21	Sas Nagar	31000	0	31000	9370	5247
22	Tarn Taran	186000	58000	127000	122070	68359
	Total	3103000	511000	2592000	1780930	997321

Annexure-VIII

District-wise numbers of various Machines distributed to the Individual farmers and Custom Hiring Centres in the State of Punjab

Name of Machine	Amritsar	Barnala	Bathinda	Fatehgarh Sahib	Ferozpur	Fardkot	Fazilka	Gurdaspur	Hoshiarpur	Jalandhar	Kapurthala	Ludhiana	Manisa	Moga	Pathankot	Patiala	Roopnagar	Sangrur	SBS Nagar	Muktsar	SAS Nagar	Tam Taran	Total
Super SMS	70	210	259	200	312	142	38	69	43	225	146	327	129	396	9	293	25	463	113	44	33	88	3634
Happy Seeder	335	706	883	254	512	367	103	314	149	304	388	1038	976	767	21	519	103	1050	95	361	26	487	9758
RMB Plough	163	126	140	134	117	175	86	76	89	380	221	331	58	162	15	147	45	171	62	102	47	186	3033
Shrub Master /Cutter cum Spreader	3	0	2	13	5	7	10	12	0	4	0	0	0	3	0	7	2	2	0	12	2	2	86
Mulcher	200	87	76	194	102	65	51	92	58	434	323	289	38	107	14	142	16	149	45	51	22	238	2793
Paddy Straw Chopper	52	130	138	114	77	83	59	100	20	110	33	141	94	77	6	91	19	95	47	126	18	72	1702
Rotary Slasher	31	3	8	14	12	17	50	36	10	22	43	13	9	8	7	38	4	24	19	43	31	33	475
Zero Till Drill	149	191	265	88	124	261	239	155	47	66	38	105	357	111	7	187	52	306	39	346	73	232	3438
Rotavator	168	200	124	233	114	171	97	152	139	236	139	369	105	154	31	217	82	233	99	159	127	341	3690
Total	1171	1653	1896	1244	1375	1288	733	9006	556	1781	1331	2613	1766	1785	110	9641	348	3493	959	9244	379	9679	28009

Annexure-IX

District-wise numbers of various Machines distributed to the Individual farmers and Custom Hiring Centres in the State of Haryana

S. No	Name of District	Custom Hiring Centres established (Nos.)	Numbers of Machinery distributed to Custom Hiring Centres and Individual Farmers							Total	
			Happy Seeder	Paddy Straw Copper/Mulcher	Rev. M.B. Plough	Rotavator	SMS	Zero Till Drill	Rotary Slasher		Shrub Master
1	KARNAL	133	215	242	131	175	214	210	44	1	1232
2	KAITHAL	140	222	134	101	171	54	219	58	18	977
3	JIND	141	227	104	61	163	47	265	24	4	895
4	KURUKSHETRA	140	217	180	222	175	52	177	23	81	1127
5	FATEHABAD	137	522	172	94	173	227	320	24	53	1585
6	SONIPAT	84	120	110	83	114	17	136	13	2	595
7	SIRSA	57	341	185	97	92	104	368	29	2	1218
8	AMBALA	75	112	84	58	106	45	84	8	10	507
9	Y.NAGAR	71	104	69	73	102	54	94	21	32	549
10	PANIPAT	78	109	145	83	108	42	99	11	7	604
11	HISAR	10	31	2	23	30	18	100	0	0	204
12	ROHTAK	50	66	60	48	102	19	174	6	2	477
13	JHAJAR	24	34	34	27	59	1	84	1	0	240
14	PALWAL	31	33	42	29	52	9	72	1	0	238
15	BHIWANI	9	8	6	10	29	3	56	2	0	114
16	PANCHKULA	5	5	9	7	15	2	19	0	4	61
17	REWARI	5	5	0	7	15	0	12	0	0	39
18	FARIDABAD	4	4	1	3	14	0	24	0	0	46
19	GURUGRAM	0	0	1	0	9	0	7	0	0	17
20	MEWAT	0	1	1	2	10	1	7	0	0	22
TOTAL		1194	2376	1581	1159	1714	909	2527	265	216	10747

Annexure-X

Division-wise and District-wise numbers of various machines distributed to the Individual farmers in the State of Uttar Pradesh

Sl.No.	Division	District	CHC (Nos)	Number of Machinery distributed to individual farmers								
				Rotavator	Happy Seeder	Revers-ible MB Plough	Zero Till Drill	Mulcher	SMS	Straw Chopper	Rotary Slasher	Shrub Master
1	Saharanpur	Muzaffar Nagar	244	430	0	8	9	4	0	0	0	
2	Saharanpur	Shamli	51	322	0	0	28	2	0	0	0	
3	Saharanpur	Saharanpur	155	428	0	0	68	3	0	0	0	
	Total		450	1180	0	8	105	9	0	0	0	
4	Meerut	Ghaziabad	6	127	0	1	22	0	0	1	0	
5	Meerut	GautamBuddh Nagar	3	72	0	0	7	0	0	1	0	
6	Meerut	Bulandshahar	142	844	0	0	35	0	0	0	0	
7	Meerut	Baghpat	44	160	0	0	1	3	0	0	0	
8	Meerut	Meerut	33	279	0	4	3	2	0	0	0	
9	Meerut	Hapur	8	181	1	0	7	0	0	0	0	
	Total		236	1663	1	5	75	5	0	2	0	
10	Aligarh	Aligarh	42	436	0	0	10	0	0	0	0	
11	Aligarh	Etah	3	68	0	0	0	0	0	0	0	
12	Aligarh	Kashganj	2	77	0	0	2	1	0	0	0	
13	Aligarh	Hathras	0	198	0	0	3	0	0	0	0	
	Total		47	779	0	0	15	1	0	0	0	
14	Agra	Agra	52	162	0	5	25	0	0	0	0	
15	Agra	Firozabad	17	70	0	0	2	0	0	0	0	
16	Agra	Mathura	35	474	3	1	235	3	0	5	0	
17	Agra	Mainpuri	4	48	0	0	0	0	1	0	0	
	Total		108	754	3	6	262	3	1	5	0	
18	Bareilly	Pilibhit	45	157	0	1	17	3	0	0	0	
19	Bareilly	Badayun	8	195	0	3	1	0	0	0	0	

20	Bareilly	Bareilly	17	66	1	4	7	3	0	0	0	0	0
21	Bareilly	Shahjhanpur	60	466	1	10	38	5	0	2	0	0	0
		Total	130	884	2	18	63	11	0	2	0	0	0
22	Moradabad	Amroha	130	326	0	1	8	0	0	0	0	0	0
23	Moradabad	Bijnour	237	375	0	18	44	2	0	0	0	0	6
24	Moradabad	Moradabad	14	285	6	16	44	3	0	0	0	0	0
25	Moradabad	Rampur	31	97	1	2	18	0	0	0	0	0	0
26	Moradabad	Sambhal	16	219	0	1	6	0	0	0	0	0	0
		Total	428	1302	7	38	120	5	0	0	0	0	6
27	Kanpur	Etawah	18	117	1	0	0	2	0	0	0	0	3
28	Kanpur	Auraiya	0	38	1	0	1	1	0	0	0	0	0
29	Kanpur	KANNAUJ	1	130	0	0	3	0	0	0	0	0	0
30	Kanpur	Kanpur Rural	26	249	0	0	5	0	0	0	0	0	0
31	Kanpur	Kanpur	13	160	0	0	7	1	0	0	0	0	0
32	Kanpur	Farrukhabad	8	113	0	0	2	1	0	0	0	0	0
		Total	66	807	2	0	18	5	0	0	0	0	3
33	Allahabad	Kaushambi	4	72	0	0	2	1	0	2	0	0	0
34	Allahabad	Pratapgarh	6	178	0	1	2	1	0	0	0	0	0
35	Allahabad	Prayagraj	4	63	0	0	7	0	0	0	0	0	0
36	Allahabad	Fatehpur	44	224	0	0	1	0	0	0	0	0	0
		Total	58	537	0	1	12	2	0	2	0	0	0
37	Jhansi	Jalaun	17	271	0	77	1	0	0	0	0	0	0
38	Jhansi	Jhansi	28	91	0	8	7	0	0	0	0	0	0
39	Jhansi	Lalitpur	73	3	0	6	7	0	0	0	0	0	0
		Total	118	365	0	91	15	0	0	0	0	0	0
40	Chitrakut	Chitrakut	0	28	0	2	0	0	0	0	0	0	0
41	Chitrakut	Banda	3	74	0	0	3	1	0	0	0	0	0
42	Chitrakut	Mahoba	96	19	0	7	5	0	0	0	0	0	0
43	Chitrakut	Hamirpur	84	12	0	7	4	0	0	0	0	0	0
		Total	183	133	0	16	12	1	0	0	0	0	0
44	Varanasi	Ghazipur	9	155	0	0	7	0	2	0	0	0	0

45	Varanasi	Chandouli	24	36	0	0	0	13	0	0	0	0	0	0
46	Varanasi	Jaunpur	3	134	0	0	0	2	0	0	0	0	0	0
47	Varanasi	Varanasi	1	63	0	0	0	1	0	0	0	0	0	0
	Total		37	388	0	0	0	23	0	2	0	0	0	0
48	Vindhyachal	Bhadohi	1	62	0	0	0	3	0	0	0	0	0	0
49	Vindhyachal	Mirzapur	6	100	0	1	0	24	4	1	0	0	0	0
50	Vindhyachal	Sonbhadra	3	41	0	0	0	7	0	0	0	0	0	0
	Total		10	203	0	1	1	34	4	1	0	0	0	0
51	Azamgarh	Azamgarh	4	163	0	2	0	0	1	0	0	0	0	0
52	Azamgarh	Balia	1	70	0	0	0	0	1	0	0	0	0	0
53	Azamgarh	Mau	3	62	0	0	0	0	1	1	0	0	0	0
	Total		8	295	0	2	0	0	3	1	0	0	0	0
54	Gorakhpur	Kushinagar	4	149	0	1	0	1	1	0	0	0	0	0
55	Gorakhpur	Gorakhpur	5	209	2	0	0	5	2	0	1	0	0	0
56	Gorakhpur	Deoria	14	204	2	4	0	7	2	0	0	1	0	0
57	Gorakhpur	Maharajan	11	113	0	1	0	0	0	0	1	0	0	0
	Total		34	675	4	6	13	13	5	0	2	1	0	0
58	Basti	Basti	46	412	4	13	0	9	2	0	3	9	1	0
59	Basti	SantkabirNagar	1	54	0	0	0	0	0	0	0	0	0	0
60	Basti	Siddhrthnagar	2	127	0	1	0	0	0	0	0	1	0	0
	Total		49	593	4	14	14	9	2	0	3	10	1	0
61	Faizabad	Amethi	9	148	0	0	0	0	1	0	0	0	0	0
62	Faizabad	Ambedkamagar	7	326	0	1	0	0	2	0	0	0	0	0
63	Faizabad	Ayodhya	2	196	0	0	0	1	0	0	1	0	0	0
64	Faizabad	Barabanki	38	426	0	8	0	4	1	1	0	0	1	0
65	Faizabad	Sultanpur	11	373	1	0	0	6	0	0	0	0	0	0
	Total		67	1469	1	9	9	11	4	1	1	0	1	0
66	Devipatan	Gonda	47	408	0	2	0	0	1	0	0	0	0	0
67	Devipatan	Balrampur	2	121	0	5	0	0	0	0	0	0	0	0
68	Devipatan	Bahraich	7	321	0	0	0	1	1	0	0	0	0	0
69	Devipatan	Shrawasti	26	92	0	0	0	0	0	0	2	0	0	0

Total		82	942	0	7	1	2	0	2	0	0
70	Lucknow										0
	Unnao	10	438	0	0	4	0	1	0	0	0
71	Lucknow	7	268	0	0	2	0	1	0	0	0
	Raibareilly										
72	Lucknow	39	273	0	0	12	0	0	0	0	1
	Lucknow										
73	Lucknow	46	325	0	2	45	0	0	2	0	0
	Lakhimpur-khiri										
74	Lucknow	29	372	0	2	7	2	0	0	0	0
	Sitapur										
75	Lucknow	58	540	0	7	48	1	0	6	0	1
	Hardoi										
Total		189	2216	0	11	118	3	2	8	0	2
Grand Total		2300	15115	24	232	906	65	8	27	11	13

Annexure-XI

Details of Area managed by In-situ CRM machinery purchased under Individual category Component and Custom Hiring Centres in the State of Punjab

Districts	Area Managed by different in-situ crop residue management machinery provided during 2018-19 (ha)							
	SMS	Happy Seeder	Paddy Straw Chopper/ Mulcher	Reversible MB Plough	Zero Till Drill	Rotavator	Rotary Slasher/ Shrub Master	Total
AMRITSAR	0	26500	3500	0	12000	0	0	42000
BARNALA	14994	34060	1894	1622	5142	0	0	57712
BATHINDA	0	23000	5300	0	21000	36000	0	85300
FATEHGARH SAHIB	44125	9660	0	0	985	0	0	54770
FEROZPUR	0	29400	220	0	19620	0	0	49240
FARIDKOT	157.2	3115.2	1000.4	0	3262	3846.8	0	11381.6
FAZILKA	3456	4757	4178	2086	21884	0	3926	40287
GURDASPUR	8500	23500	4700	0	45900	0	0	82600
HOSHIARPUR	15276	5260	0	0	1719	0	0	22255
JALANDHAR	0	22707	29863	0	15000	0	0	67570
KAPURTHALA	32104.4	21896.8	12027.2	4772.8	21896.8	0	0	92698
LUDHIANA	0	51206.1	27781.37	13768.8	16678.9	0	0	109435.2
MANSA	0	24419	2326	0	32559	10465	0	69769
MOGA	48945	0	0	0	27827	37395	0	114167
PATHANKOT	0	24	0	0	11200	0	0	11224
PATIALA	0	16512	0	0	85089	77986	0	179587
RUPNAGAR	0	0	0	0	0	0	0	0
SANGRUR	0	77300	0	0	43700	133850	0	254850
SBS NAGAR)	0	5000	0	0	2000	0	0	7000
MUKTSAR	5076	34722	0	0	59850	0	0	99648
SAS NAGAR	0	2840	1620	0	13260	0	0	17720
TARN TARAN	10650	33650	12900	12720	33450	30238	0	133608
Total	183283.6	449529.1	107310	34969.6	494022.7	329780.8	3926	1602822

Annexure-XII

Details of Area managed by In-situ CRM machinery purchased under Individual category Component and Custom Hiring Centres in the State of Haryana

S. No	Name of District	SMS		Happy Seeder		Straw Chopper		Mulcher		Shrub Master		Reversible M.B. Plough		Rotary Slasher		Zero Till Seed Drill		Rotavator		Total	
		Farmer Benefit	Area Managed	Farmer Benefit	Area Managed	Farmer Benefit	Area Managed	Farmer Benefit	Area Managed	Farmer Benefit	Area Managed	Farmer Benefit	Area Managed	Farmer Benefit	Area Managed	Farmer Benefit	Area Managed	Farmer Benefit	Area Managed	Farmer Benefit	Area Managed
1	KARNAL	496	4656	421	2899	300	1557	363	2225	0	0	365	1305	90	636	928	5759	1540	10545	9503	29582
2	KAITHAL	3650	22550	8050	6700	940	2810	233	450	125	1149	550	1100	1190	4700	8200	32750	3500	18500	26438	90709
3	JIND	3918	12962	4020	7072	310	1262	64	200	38	124	254	780	350	1337	9100	52485	5345	39229	23399	115451
4	KURUKSHETRA	350	5689	2586	2964	542	2830	338	2079	623	4350	740	3156	149	1044	504	3598	1118	7377	6950	33087
5	FATEHABAD	2302	40212	1823	3374	234	5237	15	920	25	1200	25	500	7	15	887	7753	510	3300	5828	62511
6	SONIPAT	507	1995	1359	1097	240	860	199	536	4	6	274	653	334	578	1600	3781.5	3657	9290	8174	18796.5
7	SIRSA	1715	15485	1307	2435	430	2342	258	1248	0	0	307	1265	130	964	540	3259	1140	6385	5827	33383
8	AMBALA	717	3820	3313	1755	364	1930	180	935	67	332	306	1592	0	0	971	4892	1341	6501	7259	21757
9	YAMUNASOTER	3635	17122	2718	5684	880	2688	1476	4720	21	44	894	2410	274	634	5764	31778	24576	77458	40238	142538
10	PANIPAT	647	7290	2330	2233	1513	2363	914	1561	1	5	324	579	14	25	724	1722	3162	8190	9629	23968
11	HISAR	79	334.5	342.2	304.5	34	111	32	122.4	0	0	38	101	0	0	101	390.1	148	488.3	774.2	1851.8
12	ROHTAK	348	1387	316	1291	17	44.5	168	626	1	1	39	147	0	0	770	2797	777	3998	2436	10291.5
13	JHAJAJAR	20	80	218	112	90	168	196	307	0	0	117	207	0	0	664	1627	1240	2063	2545	4564
14	PALWAL	70	305	125	42	938	2814	87	421	0	0	264	785	28	100	688	1135	596	2438	2796	8040
15	BHIWANI	232	620	60	145	2	2	30	110	0	0	38	125	18	55	552	2510	460	2020	1392	5587
16	PANCHKULA	0	0	0	0	27	30	6	14	186	337	76	137	0	0	521	666	323	494	1139	1678
17	REWARI	0	0	6.25	6	0	0	37	40	0	0	36	47.25	0	0	63	94.5	276	339.75	418.25	527.5
18	FARIDABAD	0	0	305	7	4	60	0	0	0	0	6	90	0	0	80	380	90	1750	485	2287
19	GURUGRAM	80	200	0	0	4	5	0	0	0	0	19	34	0	0	65	248	283	830	451	1317
20	MEWAT	0	0	0	0	0	0	5	20	0	0	0	0	0	0	42	210	70	280	117	510
	Total	18766	134707.5	12456	134707.5	6869	27113.5	4601	16534.4	1091	7548	4672	15013.25	2554	10088	32764	157835.1	56152	201476.1	133955	705023.4

District-wise number of Fire events in the State of Punjab

Districts	Fire Events (01 Oct - 30Nov)			Percent reduction/ increase in fire events during 2018	
	2016	2017	2018	w.r.t. 2016	w.r.t. 2017
AMRITSAR	2171	1368	1406	35.2	+2.8
BARNALA	5701	3430	3279	42.5	4.4
BATHINDA	8846	5783	6348	28.2	+9.8
FARIDKOT	4630	3472	3058	34.0	11.9
FATEHGARH SAHIB	2461	1643	866	64.8	47.3
FEROZPUR	13645	9957	9993	26.8	+0.4
GURDASPUR	2221	1599	1172	47.2	26.7
HOSHIARPUR	905	497	199	78.0	60.0
JALANDHAR	4663	2134	1395	70.1	34.6
KAPURTHALA	3136	1627	751	76.1	53.8
LUDHIANA	9546	4769	3053	68.0	36.0
MANSA	5652	4506	4317	23.6	4.2
MOGA	6393	2786	2730	57.3	2.0
MUKTSAR	7037	5458	5786	17.8	-6.0
SBS NAGAR	1366	691	305	77.7	55.9
PATIALA	6546	5034	4217	35.6	16.2
RUPNAGAR	719	329	91	87.3	72.3
SANGRUR	11862	8430	7782	34.4	7.7
SAS NAGAR	366	246	199	45.6	19.1
TARN TARAN	4513	3320	2748	39.1	17.2
Total	102379	67079	59695	41.7	11.0

District-wise number of Fire events in the State of Haryana

Districts	Fire Events (01 Oct - 30Nov)			Percent reduction/ increase in fire events during 2018	
	2016	2017	2018	w.r.t. 2016	w.r.t. 2017
AMBALA	538	504	334	37.9	33.7
BHIWANI	93	49	22	76.3	55.1
FARIDABAD	288	343	188	34.7	45.2
FATEHABAD	4833	3749	2554	47.2	31.9
GURUGRAM	0	0	0	0	0
HISAR	416	195	214	48.6	+9.7
JHAJJAR	43	19	35	18.6	+84.2
JIND	862	946	889	+3.1	6.0
KAITHAL	1748	1513	1292	26.1	14.6
KARNAL	1640	1514	857	47.7	43.4
KURUKSHETRA	1080	1152	683	36.8	40.7
MAHENDRAGARH	0	0	0	0	0
MEWAT	0	0	0	0	0
PALWAL	0	0	0	0	0
PANCHKULA	0	0	3	0	0
PANIPAT	102	110	65	36.3	40.9
REWARI	0	0	0	0	0
ROHTAK	103	100	53	48.5	47.0
SIRSA	3580	2479	1790	50.0	27.8
SONIPAT	102	87	45	55.9	48.3
YAMUNANAGAR	258	325	208	19.4	36.0
Total	15686	13085	9232	41.1	29.4

District-wise number of Fire events in the State of Uttar Pradesh

Districts	Fire Events (01 Oct - 30Nov)			Percent reduction/ increase in fire events during 2018	
	2016	2017	2018	w.r.t. 2016	w.r.t. 2017
AGRA	0	0	0	0	0
ALIGARH	60	83	95	+58.3	+14.5
ALLAHABAD	8	20	22	+175.0	+10.0
AMBEDKAR NAGAR	80	71	36	55.0	49.3
AMETHI	0	0	0	0	0
AMROHA	0	0	0	0	0
AURAIYA	291	263	82	71.8	68.8
AZAMGARH	38	58	38	0.0	34.5
BADAUN	15	14	15	0.0	+7.1
BAGHPAT	0	0	0	0	0
BAHRAICH	85	42	60	29.4	+42.9
BALLIA	19	48	35	+84.2	27.1
BALRAMPUR	39	28	46	+17.9	+64.3
BANDA	2	23	13	+550.0	43.5
BARABANKI	222	168	175	21.2	+4.2
BAREILLY	271	240	126	53.5	47.5
BASTI	147	187	127	13.6	32.1
BHADOHI	0	0	0	0	0
BIJNOR	88	79	25	71.6	68.4
BULANDSAHAR	39	41	30	23.1	26.8
CHANDAUJI	22	28	6	72.7	78.6
CHITRAKOOT	0	0	0	0	0
DEORIA	62	86	82	+32.3	4.7
ETAH	24	33	28	+16.7	15.2
ETAWAH	189	148	77	59.3	48.0
FAIZABAD	20	16	13	35.0	18.8
FARRUKHABAD	0	0	0	0	0
FATEHPUR	90	76	95	+5.6	-25.0
FIROZABAD	23	18	11	52.2	38.9
GAUTAMBUDH NAGAR	33	48	13	60.6	72.9
GAZIPUR	16	27	33	-106.3	+22.2
GHAZIABAD	102	73	49	52.0	32.9
GONDA	52	39	23	55.8	41.0
GORAKHPUR	67	115	143	+113.4	+24.3
HAMIRPUR	0	0	2	0	0
HAPUR	0	0	0	0	0

CROP RESIDUE MANAGEMENT

HARDOI	260	211	118	54.6	44.1
HATHRAS	0	0	0	0	0
JALAUN	0	0	0	0	0
JAUNPUR	27	46	28	+3.7	39.1
JHANSI	0	0	2	0	0
KANNAUJ	35	20	8	77.1	60.0
KANPUR	20	14	13	35.0	7.1
KANPUR DEHAT	75	76	30	60.0	60.5
KASGANJ	0	0	0	0	0
KAUSHAMBI	37	60	53	+43.2	11.7
KHERI	525	371	256	51.2	31.0
KUSHINAGAR	70	157	179	+155.7	+14.0
LALITPUR	0	0	0	0	0
LUCKNOW	64	30	26	59.4	13.3
MAHARAJGANJ	744	1029	1092	+46.8	+6.1
MAHOBA	0	0	0	0	0
MAINPURI	97	97	62	36.1	36.1
MATHURA	1463	1083	1051	28.2	3.0
MAU	15	24	25	+66.7	+4.2
MEERUT	123	128	40	67.5	68.8
MIRZAPUR	6	24	10	+66.7	58.3
MORADABAD	69	48	21	69.6	56.3
MUZAFARNAGAR	192	202	76	60.4	62.4
PILHIBHIT	970	752	439	54.7	41.6
PRATAPGARH	47	65	45	4.3	30.8
RAE BARELI	120	153	80	33.3	47.7
RAMPUR	640	667	230	64.1	65.5
SHARANPUR	144	166	85	41.0	48.8
SAMBHAL	0	0	0	0	0
SANTKABIR NAGAR	56	65	56	0.0	13.8
SHAHJAHANPUR	1163	718	400	65.6	44.3
SHAMALI	0	0	0	0	0
SHRAWASTI	39	32	37	5.1	+15.6
SIDDHARTH NAGAR	266	188	477	+79.3	+153.7
SITAPUR	152	88	48	68.4	45.5
SONBHADRA	17	20	14	17.6	30.0
SULTANPUR	82	93	71	13.4	23.7
UNNAO	68	60	42	38.2	30.0
VARANASI	2	0	0	100.0	0
JYOTIBAPHULE NAGAR	13	22	14	+7.7	36.4
MAHAMAYANAGAR	4	3	8	+100.0	+166.7
Total	9709	8784	6636	31.7	24.5

Annexure-XVI
Effect of Continuous Residue Management Practices for 10 Years on Organic Carbon (%) in Rice-Wheat System (Year-wise)

Treatments		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
A.	Planting without crop residue											
1	T transplanted rice without wheat straw	Zero Till Wheat without rice straw	0.330	0.340	0.360	0.378	0.400	0.411	0.416	0.432	0.442	0.446
2	Transplanted rice without wheat straw	Conventional Wheat without rice straw	0.323	0.339	0.337	0.349	0.371	0.405	0.409	0.413	0.418	0.420
3	ZT Rice without Wheat Straw (DSR)	ZT Wheat without Rice Straw	0.335	0.341	0.370	0.381	0.385	0.410	0.414	0.417	0.422	0.424
B	Planting with Rice Residue in Wheat											
4	Transplanted rice without wheat straw	Zero Till Wheat with rice straw (Happy Seeder)	0.339	0.350	0.380	0.391	0.482	0.523	0.610	0.622	0.648	0.679
5	ZT Rice without Wheat Straw (DSR)	Zero Till Wheat with rice straw (Happy Seeder)	0.334	0.357	0.380	0.397	0.412	0.481	0.504	0.520	0.543	0.548
6	Transplanted rice without wheat straw	CT Wheat with Rice Straw (Incorporated)	0.338	0.340	0.362	0.387	0.430	0.540	0.650	0.740	0.741	0.746
7	Transplanted rice without wheat straw	ZT Wheat with Rice Straw (Rotavator)	0.331	0.354	0.371	0.390	0.415	0.500	0.613	0.670	0.678	0.683
C	Planting with both Rice and Wheat Straw											
8	Transplanted rice with wheat straw	Zero Till Wheat with rice straw (Happy Seeder)	0.336	0.360	0.390	0.435	0.522	0.591	0.685	0.710	0.737	0.746
D	Planting after Burning of Residue											
9	Transplanted rice after burning of wheat straw	ZT Wheat after partial burning of Rice Straw	0.330	0.334	0.354	0.365	0.389	0.419	0.435	0.450	0.478	0.486