

PROCEEDINGS

Stakeholders' Workshop on Crop Residue Management: Convergence and Synergy for Sustainable Solutions

30 September 2026



**ICAR-Agricultural Technology Application Research Institute, Ludhiana
&
Punjab Agricultural University, Ludhiana**

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ICAR-Agricultural Technology Application Research Institute (ATARI), Zone-I, Ludhiana, in collaboration with Punjab Agricultural University (PAU), Ludhiana organised the **Stakeholders' Workshop on Crop Residue Management: Convergence and Synergy for Sustainable Solutions** on 30 September 2026 at the Dr. Khem Singh Gill Farmers Service Centre, PAU, Ludhiana, under the chairmanship of **Sh. Sukhjot Pal Singh, IAS & Vice-Chancellor, PAU, Ludhiana**. The workshop brought together more than 175 participants including senior agricultural scientists, ICAR and SAU representatives, officials from the Department of Agriculture and Farmers' Welfare, KVKs, farmers, Custom Hiring Centres (CHCs), machinery manufacturers, NGOs, foundations, private-sector organizations and other stakeholders from Punjab, Haryana, Uttar Pradesh and Madhya Pradesh.



The workshop was attended by **Dr. Ranjay Kumar Singh**, ADG (Agricultural Extension), ICAR; **Dr. Parvender Sheoran**, Director, ICAR-ATARI Zone-I, Ludhiana; **Dr. J. P. Mishra**, Director, ICAR-ATARI Zone-II; **Dr. M. S. Bhullar**, Director of Extension Education, PAU; **Dr. Ajmer Singh Dhatt**, Director of Research, PAU, along with representatives of research and extension institutions, NGOs, SHGs, CHCs, machinery manufacturers and farmers.

Inaugural and Opening Session

The workshop was initiated by **Dr. G. S. Makkar**, who emphasized that crop residue burning is a complex, multi-dimensional issue that cannot be addressed by any single institution, technology, machinery or sector. He stressed the need for a coordinated and convergent approach involving **research institutions, government departments, industry, farmers, extension agencies and civil society organizations**.

He highlighted the need to strengthen convergence between **science and policy, technology and field experience, and government and industry**. Scientific innovations must be translated into practical field-level solutions, while farmers' experiences and field realities should simultaneously inform research, technology development and policy formulation.

Welcoming the participants, **Dr. M. S. Bhullar** stated that the research community strongly supports in-situ residue management because of its benefits for soil health. At the same time, he emphasized the need to understand the practical difficulties associated with retaining paddy residue in the field and to address the issue of residue generation through appropriate interventions in rice-based cropping systems.

He also highlighted the need to rationalize the efforts of different organizations. Areas receiving inadequate attention should be prioritized, while duplication of activities in the same geographical areas should be avoided. The ultimate objective should be **100% crop residue management and a completely burning-free Punjab**.

Status and Context

Dr. Parvender Sheoran, Director, ICAR-ATARI Zone-I and Nodal Officer for CRM, presented the status of crop residue generation and burning, and highlighted emerging trends across Punjab, Haryana, Uttar Pradesh, Delhi and Madhya Pradesh.

He noted that the rice-wheat system of north-western India generates a very large quantity of rice residue, with Punjab contributing the major share. Since the launch of the Central Sector Scheme on Crop Residue Management in 2018-19, substantial investment has been made in awareness generation and machinery support. A wide range of technologies is now available for both *in-situ* and *ex-situ* management.



He highlighted that in Zone-I, **60 KVKs have been implementing IEC activities in 1,241 villages, with 988 villages reported as burning-free**, while also drawing attention to the relatively low utilization of available machinery. Only about **35-40% of machinery available with farmers and CHCs was reported to be effectively utilized**. The need to rationalize machinery distribution, strengthen monitoring, and promote a circular economy based on **Reduce, Reuse, and Recycle** was emphasized.

Dr. Sheoran proposed **CRM-CONNECT (Collaborative Outreach & Network for New Extension, Convergence & Technology)** as a common platform for hotspot-focused intervention, convergence among stakeholders, and integration of *in-situ* and *ex-situ* CRM approaches.



Session I: *In-Situ* Management - Mechanization, CHCs and Technology Solutions

The first technical session focused on the performance, suitability, accessibility, and utilization of *in-situ* CRM technologies.

Farmers shared extensive field experiences with **Happy Seeder, Smart Seeder, Super Seeder, mulching, and residue incorporation**. Farmers practicing residue retention for several years reported improvements in soil health, nutrient recycling, and reduced dependence on external inputs. One farmer reported an increase in soil organic carbon from 0.25% in 2009 to 0.75% in 2021 under long-term residue retention.

Farmers also reported that Happy Seeder technology can facilitate timely wheat sowing, reduce weed emergence, and support crop establishment under adverse weather conditions. Residue mulching was reported to be beneficial in crops such as potato, onion, and garlic.

At the same time, participants emphasized that the performance of CRM machinery is highly dependent on **soil type, residue load, field conditions, machine settings, tractor power, and operator skill**. It was observed that machinery should not be recommended uniformly across all situations.

Dr. Parvender Sheoran emphasized that every CRM machine has a specific operational domain and should be used accordingly. Farmers should receive technical guidance before purchasing machinery, and simple technical advisories should clearly specify the suitability, limitations, and operating conditions of each machine.

The workshop also identified **under-utilization of existing machinery** as a more important concern than the mere availability of additional machines. Participants cautioned against continuously adding new machinery when suitable technologies are already available but inadequately utilized.

The need for improved machinery mobilization, rationalization of machinery among districts, strengthening of CHCs and mandatory training of operators was highlighted. IPS Foundation developed an integrated machinery dashboard, which had been implemented in selected districts, and proposed its scaling up across Punjab for systematic monitoring of machinery availability, location, utilization and deployment.

Special attention was drawn to **border areas, waterlogged areas, saline soils and other difficult agro-ecological situations**, where conventional in-situ technologies may not always be suitable. Participants recommended field-level surveys and location-specific technological solutions.

Session II: *Ex-Situ* Management - From Paddy Straw to Value, Energy and Carbon

The second session examined whether *ex-situ* management could provide a viable long-term pathway for surplus crop residue.

Dr. Harinder Singh Sidhu, Chief Agriculture Officer, Mansa, highlighted the growing acceptance of baling among farmers and argued that *ex-situ* management should not be overlooked. Farmers often prefer clean fields, and baling can provide a practical alternative where in-situ management is difficult. The availability of balers and demand from biomass-based industries, CBG plants and other users create opportunities for residue-based enterprises.

Farmers and entrepreneurs shared examples of economic opportunities generated through baling. **Joga Singh of the Singhpura Group, Patiala**, reported that baling activities were generating employment and income and that paddy straw was being utilized for CBG, pellets and energy production. At the same time, participants highlighted the increasing cost of collection and baling operations and the need for viable pricing mechanisms.

However, the workshop also identified significant limitations of *ex-situ* management. These included:



- ❖ high collection, baling and transportation costs;
- ❖ inadequate storage facilities;
- ❖ accumulation of bales and temporary dumping yards;
- ❖ transportation difficulties from interior villages;
- ❖ inadequate year-round demand;
- ❖ insufficient after-sales support for machinery;
- ❖ absence of insurance mechanisms for stored bales; and
- ❖ potential nutrient mining and deterioration of soil health under continuous residue removal.

Farmers shared contrasting experiences. Some reported economic benefits from baling, while others indicated that the financial benefits accrued largely to baler operators rather than farmers and expressed concern regarding declining soil health after continuous residue removal.

The workshop therefore arrived at an important principle: **ex-situ management should be treated as a complementary pathway for genuine surplus residue and not as a blanket replacement for in-situ management.**

It was emphasized that where baling is undertaken, sufficient residue should remain in the field to maintain soil health and nutrient cycling.

Session III: Reducing Residue Generation - Cropping System Diversification and Sustainable Agriculture

The third session shifted the discussion from managing residue after harvest to **reducing the quantity of residue generated in the first place.**

Participants emphasized the importance of **crop diversification, short- and medium-duration rice varieties, DSR, summer moong, kharif maize, agroforestry, and other alternative production systems.**

It was noted that diversification cannot be achieved through technology alone. Farmers require **assured markets, remunerative prices, crop insurance, protection against wildlife damage, and suitable institutional support.** In some areas, farmers hesitate to adopt alternative crops because of crop damage by nilgai and other wildlife.

The issue of land tenancy was also discussed. Short-term tenancy and multiple layers of tenancy can create pressure for maximizing immediate returns, potentially discouraging investments in long-term soil health.

The importance of **green manuring** was highlighted as another means of maintaining soil organic matter and improving soil health.

Participants also suggested strengthening the Soil Health Card by incorporating relevant biological indicators and exploring a **"Sustainable Rice"** certification/tag based on defined sustainability parameters.

Session IV: Farmer Adoption - Awareness, Incentives, Community Action and Enforcement

The fourth session examined the human, institutional, and economic dimensions of CRM adoption.

A recurring observation was that **technology availability does not automatically result in technology adoption**. Farmers may hesitate to retain residue because of the preference for visually clean fields, concerns regarding crop establishment, lack of technical knowledge, machinery downtime, and uncertainty regarding economic returns.

Participants stressed the importance of **farmer-to-farmer extension**, field demonstrations, technology-oriented training, and local success stories.



The workshop also highlighted the importance of **Super SMS-equipped combines**. Participants recommended strict enforcement, monitoring, and appropriate support to ensure that harvested straw is uniformly spread and subsequent residue-management operations can be carried out effectively.

District-level control rooms, such as the initiative established in Amritsar in collaboration with the Punjab Pollution Control Board and Punjab Remote Sensing Centre, were suggested for wider replication across Punjab. Such mechanisms can facilitate timely monitoring, identification of hotspots, and coordinated response.

Carbon credits were recognized as an emerging incentive mechanism. However, participants emphasized the need for transparency, credible monitoring, and appropriate authorization/recognition of private carbon-credit organizations to build farmer confidence and protect farm data.

Session V: Convergence for Action - Policy, Partnerships, Financing and Way Forward

The final technical session focused on moving from individual interventions to an integrated institutional framework.

Participants discussed the need to reconsider the present subsidy architecture and explore greater support for **service providers and CHCs**, rather than focusing exclusively on individual machinery ownership. Performance-linked and phased subsidy release was also suggested.

The workshop highlighted problems associated with machinery procurement, including non-registration of manufacturers on GeM, procurement of substandard machinery, inadequate after-sales service, and lack of performance monitoring. It was suggested that machinery manufacturers should provide appropriate training and reliable repair and maintenance services.

Concluding Deliberations

In the concluding discussion, **Dr. Ajmer Singh Dhatt, Director of Research, PAU**, emphasized that the ultimate objective of CRM must remain **sustainable crop production and food security while maintaining soil health**. He noted that Punjab faces the challenge of managing a very large quantity of rice residue within a short sowing window.

He observed that although *ex-situ* CRM has developed into an economic activity and provides business opportunities for certain stakeholders, it should not compromise the long-term health of agricultural soils. He emphasized the importance of short- and medium-duration rice varieties and diversification in reducing residue generation.

The workshop broadly converged on the principle that there is **no one-size-fits-all solution**. The appropriate strategy should depend on the crop, soil, residue load, weather, machinery availability, farm size, cropping system, local infrastructure and economic conditions.

The emphasis should therefore move from a binary "*in-situ* versus *ex-situ*" debate towards a **balanced and evidence-based integration of both approaches**.

Where residue can be beneficially retained, ***in-situ* management should remain the preferred strategy** for nutrient recycling, soil organic matter, moisture conservation and long-term agricultural sustainability. Where genuine surplus exists or where field conditions make *in-situ* management impractical, **economically viable *ex-situ* pathways** should be developed for biomass, bioenergy, biofuel, CBG, pellets and other circular-economy applications.

The ultimate goal should be to transform crop residue from an environmental liability into a **productive agricultural and economic resource**, while ensuring that the soil does not become the unintended cost of residue utilization.

Dr. Ranjay Kumar Singh, ADG (Extension), ICAR, emphasized that CRM-CONNECT should be based on **transparency, trust, legitimacy of actions, and a clearly defined common mission**. He proposed that all stakeholders should meet at the earliest to define their roles and responsibilities, avoid duplication, and improve geographical coverage.

He further emphasized the need for **date-wise and location-wise mapping of burning incidents and interventions**, and documentation of successful transitions from burning to *in-situ* or *ex-situ* management.

He observed that while *ex-situ* management can provide a relatively quick solution, its long-term implications require careful consideration, and **greater emphasis should remain on sustainable *in-situ* management**.

Key Recommendations / Action Points

The following key action points emerged from the workshop:

A. Convergence and CRM-CONNECT

1. Establish **CRM-CONNECT (Collaborative Outreach & Network for New Extension, Convergence & Technology)** as a common platform for coordinated action.
2. Convene an early meeting of all stakeholders to **define institutional roles, responsibilities, geographical coverage, and timelines**.
3. Avoid duplication of activities and ensure balanced coverage of CRM interventions across districts.

4. Develop a common annual **CRM action calendar with clearly defined responsibilities and measurable outputs.**

5. Document and disseminate successful farmer, institutional, and enterprise models.

B. *In-Situ* CRM and Soil Health

6. Maintain *in-situ* residue management as the principal strategy wherever technically and agronomically feasible.

7. Promote proven technologies such as **Happy Seeder, Smart Seeder, Zero-Till Drill, suitable mulching and other validated implements**, rather than continuously adding new machinery.

8. Develop a simple **machine suitability matrix/technical advisory** specifying crop, soil, residue condition, tractor requirement, operating conditions, advantages and limitations of each machine.

9. Ensure technical guidance and field demonstrations **before farmers purchase or operate CRM machinery.**

10. Promote green manuring, residue retention and other practices that improve **soil organic carbon, biological health and nutrient cycling.**

C. Machinery Utilization and CHCs

11. Focus on **utilization and performance of existing machinery**, rather than merely increasing machine numbers.

12. Develop a centralized **Punjab CRM machinery dashboard** covering location, ownership, availability, utilization, deployment and maintenance.

13. Rationalize machinery allocation between districts and ensure that machinery sanctioned for a district is effectively utilized there.

14. Strengthen CHCs and cooperative societies through **mandatory operator training and pre-season technical orientation.**

15. Consider support for **small and appropriately sized machinery** to improve access for small and marginal farmers.

D. *Ex-Situ* CRM and Circular Economy

16. Promote *ex-situ* management selectively for **genuine surplus residue and location-specific situations**, without compromising soil health.

17. Develop integrated value chains linking **farmers-balers-aggregators-storage facilities-transporters-biomass/CBG/pellet/energy industries.**

18. Establish appropriate systems for **bale storage, transportation, insurance and fire-risk management.**

19. Strengthen after-sales service, maintenance and pre-season training for *ex-situ* machinery.

20. Develop transparent and remunerative mechanisms for **bale pricing and residue procurement.**

21. Ensure that sufficient residue remains in the field wherever complete removal may adversely affect soil health.

E. Crop Diversification and Residue Reduction

22. Promote **short and medium-duration rice varieties, DSR, summer moong, maize, agroforestry and other suitable diversification options.**
23. Support diversification through assured markets, remunerative prices, crop insurance and protection against wildlife damage.
24. Address institutional and economic constraints associated with tenancy that discourage long-term soil-health investments.

F. Monitoring and Enforcement

25. Strengthen district-level monitoring and establish **CRM control rooms** in priority districts.
26. Integrate satellite/remote sensing-based fire monitoring with field-level verification and rapid response.
27. Ensure effective implementation and monitoring of **Super SMS with combine harvesters.**
28. Monitor actual field use of CRM machinery and prevent partial burning disguised as residue management.
29. Develop specific solutions for **border areas, waterlogged/saline soils, heavy soils and other difficult agro-ecological conditions.**

G. Incentives and Carbon Markets

30. Explore **performance-linked incentives** based on actual CRM adoption, soil-health improvement and measurable environmental outcomes.
31. Strengthen carbon-credit mechanisms for residue retention and regenerative agriculture through credible **measurement, reporting and verification (MRV).**
32. Establish appropriate government recognition/authorization mechanisms for carbon-credit entities to build farmer confidence and protect farm data.

H. Evidence, Research and Knowledge

33. Undertake long-term comparative studies on **in-situ versus continuous ex-situ residue removal**, particularly with respect to soil organic carbon, nutrients, irrigation requirements, crop productivity and farm economics.
34. Develop location-specific CRM packages based on **soil type, cropping system, residue load and farm conditions.**
35. Promote farmer-to-farmer extension, travelling seminars and exposure visits, particularly for states and districts where residue-burning incidents are increasing.
36. Establish a continuous feedback mechanism through **farmers, KVKs, CHCs, industry and state departments** to improve CRM technologies and policies.

Way Forward

The workshop concluded that crop residue management must now move from a **scheme-driven machinery approach to a coordinated, outcome-oriented and sustainability-centred system**. The success of CRM should not be measured only by the number of machines distributed or fires prevented, but by the extent to which the agricultural system achieves **zero burning, improved soil health, efficient resource use, viable farmer incomes and sustainable crop production**.

The collective message of the workshop was clear: ***in-situ* and *ex-situ* management should not be treated as competing alternatives**. They should form complementary components of a **location-specific CRM strategy, with soil health and sustainable agriculture at its core and circular economy principles guiding the utilization of genuine surplus residue**.

The proposed **CRM-CONNECT** platform provides an opportunity to convert this convergence into coordinated action through defined responsibilities, transparent data, hotspot-focused interventions, technology rationalization, farmer participation and measurable outcomes. The workshop therefore marked an important step towards building a **collaborative, science-based and sustainable pathway for crop residue management and a completely burning-free agricultural system**.

The workshop was coordinated by Dr. G. S. Makkar, In-charge, Plant Clinic, ICAR-ATARI, Ludhiana. Two publications on crop residue management by ICAR-ATARI were also released on the occasion. The workshop concluded with the formal vote of thanks proposed by Dr. P. S. Sandhu, ADEE.





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