www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(1): 2457-2462

www.thepharmajournal.com
Received: 01-10-2022
Accepted: 07-12-2022

K Jaisimha Reddy
Ph.D. Scholar, Department of Agronomy, University of Agricultural Sciences, Dharwad, Karnataka, India

Shivanand Goudra
Research Associate, ZAHRS, Babbur farm, Hiriyur, UAHS, Shivamogga, Karnataka, India

Corresponding Author:
K Jaisimha Reddy
Ph.D. Scholar, Department of Agronomy, University of Agricultural Sciences, Dharwad, Karnataka, India

A review on crop residue burning: Impact and its management

K Jaisimha Reddy and Shivanand Goudra

Abstract
Harvesting of various crops generates a substantial amount of residues on and off the farm. In India, around 500 Mt of crop residues are generated annually. Cereals generate the most agricultural residues (352 Mt), followed by fibres (66 Mt), oilseeds (29 Mt), pulses (13 Mt), and sugarcane (12 Mt). Cereal crops (rice, wheat, maize, millets) produce 70% of crop residues, whereas rice alone contributes 34%. The problem is more severe in the irrigated Indo-Gangetic plains, particularly in the mechanized rice-wheat system of the northwest India (Punjab, Haryana, Uttarakhand plains and Western UP). The major constraints in the rice-wheat cropping system are less time available between rice harvest and sowing of wheat and also shortage of labour. This leads farmers towards mechanical harvesting, resulting in burning of huge amount of crop residues in the field itself. Crop residue burning leads to loss of plant nutrients such as N, P, K and S, impacts soil physicochemical, biological and microbial properties by elevating soil temperature, and also causes emission of greenhouse gases (GHGs) such as CO_2, CH_4 and N_2O causing global warming. Various technological interventions to reduce crop residue burning include incorporation of crop residue into soils through adoption of conservation agriculture practices, promotion of use of crop residue for preparation of bio enriched compost or vermicomposting, use of crop residue for cultivation of mushrooms, diversification of the use of crop residues as fuel for power plants, production of cellulosic ethanol and incentives for the purchase of happy seeder or turbo seeder or shredder or baling machines and extending subsidy to the farmers for hiring resource conservation machineries from custom hiring center or agriculture service center etc.

Keywords: Crop residues, global warming, greenhouse gases, technological interventions

1. Introduction
1.1 Global context
Crop residue burning is a worldwide occurrence, with many nations participating in this so-called menace. China, India, and the United States are the largest consumers of crop residues globally. Other major contributors to crop residue burning include Brazil, Indonesia, and the Russian Federation. Nonetheless, relative to other continents, Africa has some of the highest rates of residue burning per hectare of harvested land. It is also the zone where fires are spreading the quickest. Burning has advanced dramatically in nations such as Brazil, Indonesia, Thailand, India, and China over the past several decades.

1.2 Indian context
According to a study undertaken by the Ministry of New and Renewable Energy (2019), around 500 million tonnes of crop residues are produced annually. As per the same report, the bulk of crop residue is utilized for animal feed, fuel, and other domestic and industrial applications. However, there is still a 140 Mt surplus, of which 92 Mt are burned annually. Uttar Pradesh generates the most crop residues (60 million tonnes), followed by Punjab (51 million tonnes) and Maharashtra (46 million tons). Cereals produce the most residues (352 million tonnes), followed by fibres (66 million tonnes), oilseeds (29 million tonnes), pulses (13 million tonnes), and sugarcane (12 million tonnes). Nearly 70% of total agricultural wastes come from cereals (rice, wheat, maize, millets). Rice and wheat account for almost 58 % of all crop residues. Rice, wheat, and sugarcane account for an astounding 82% of India's total crop residue burning. Cotton contributes to 8% of the crop residue burning while jute and maize contribute 3% each.

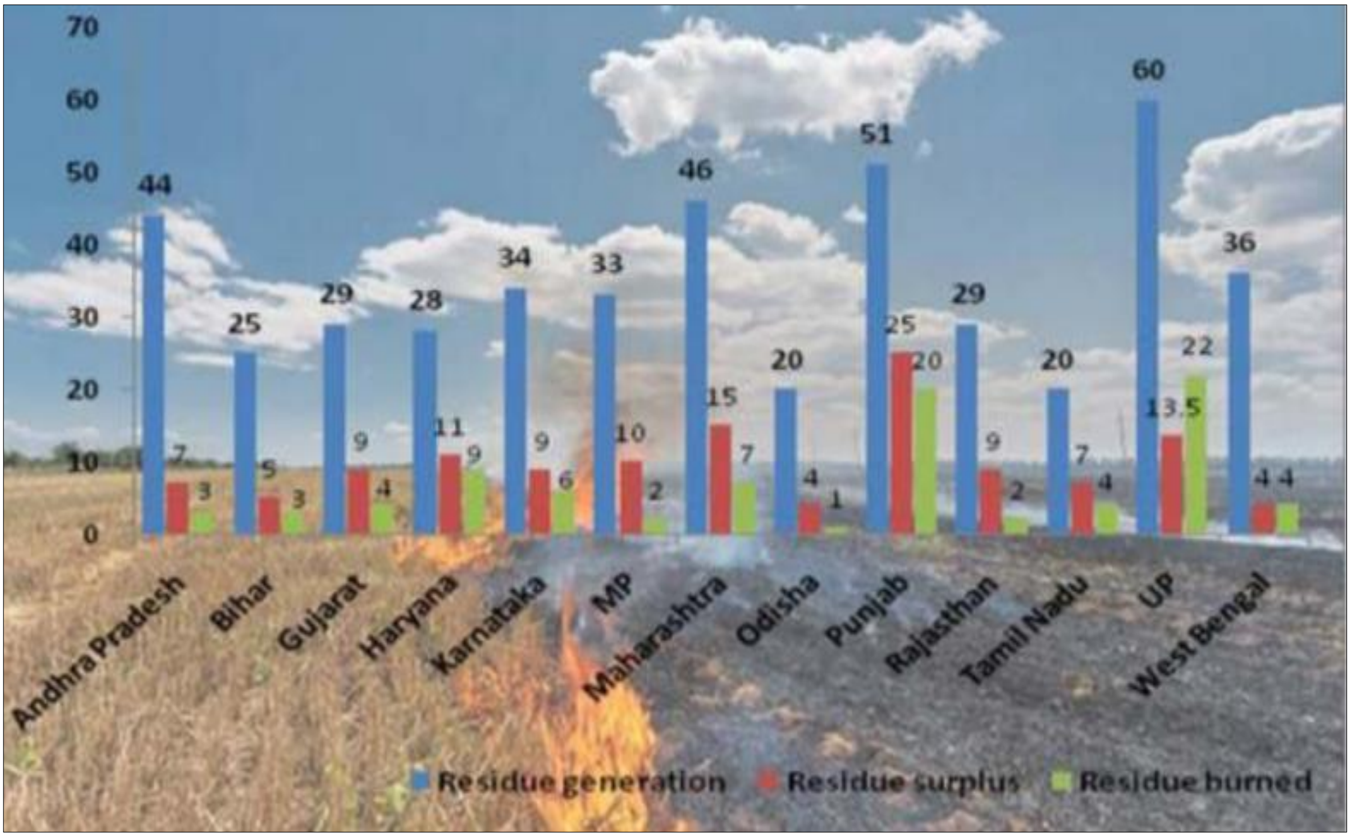


Fig 1: Residue generated, residue surplus and burned in major states (Million tons)

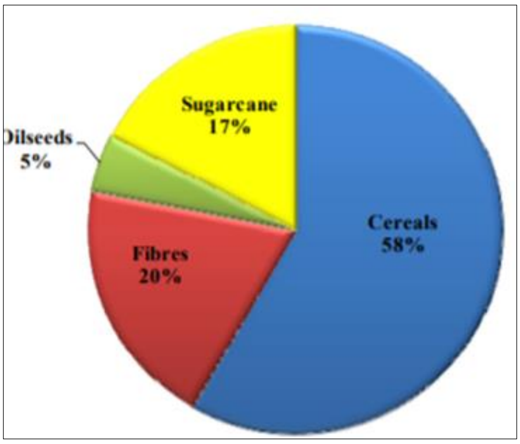


Fig 2: Contribution of different crop categories in residue generation

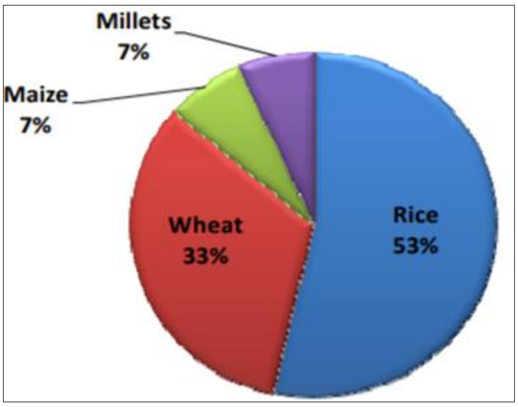


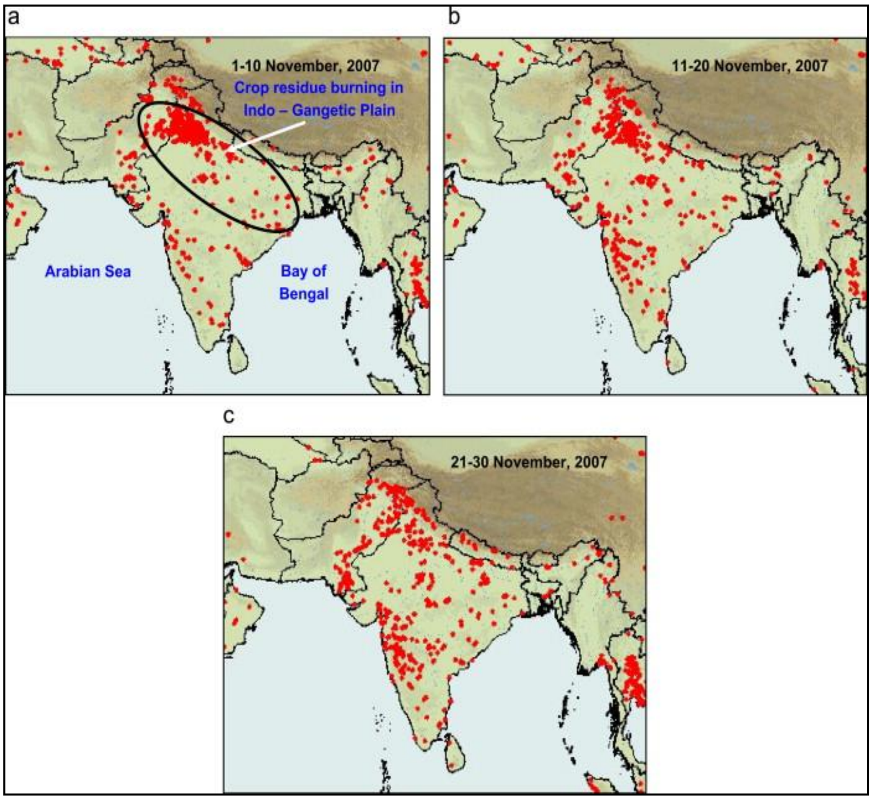
Fig 3: Contribution of different cereal categories in residue generation crops in residue generation.

1.3 Reasons for burning of crop residues in Northern India

With the availability of photo-insensitive, short-duration wheat and rice cultivars, it is now possible to cultivate high-yielding rice crops in 120–130 days. Less time between rice harvest and wheat planting, as well as a labour scarcity, prompted farmers to adopt mechanization. The mechanical harvesting using a combine harvester leaves vast quantities of stubble in the field. Therefore, farmers find that burning rice stubble is the simplest and most cost-effective way to dispose of it.

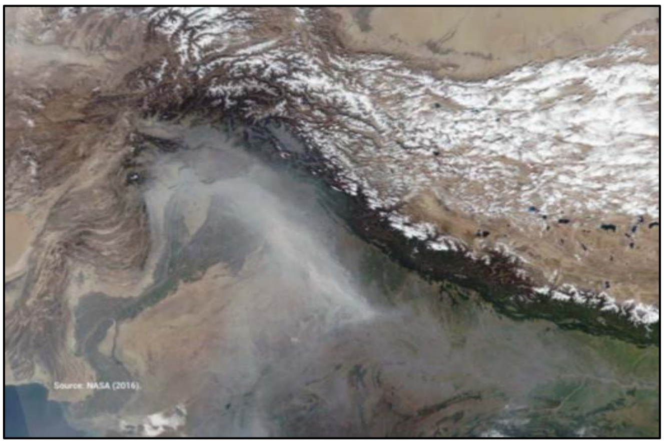
Due to the loss of ground water caused by paddy cultivation, the governments of Haryana and Punjab enacted legislation whose purpose was to preserve ground water. In 2009, both the Punjab Preservation of Subsoil Water Act and the Haryana Preservation of Subsoil Water Act were enacted. In addition to bringing the crop cycle closer to the monsoon and conserving ground water, as intended, these measures shortened the period between wheat harvests. This reduced the amount of time farmers had to remove crop debris and compelled them to burn it.

Post-harvest burning of the crop residues in Punjab, Haryana, Rajasthan, and western Uttar Pradesh increased the particulate matter significantly in the environment. Unfortunately, this occurred with the October/November onset of winter in northern India. The shift in wind direction and the decrease in temperature make it difficult to disperse the particulate matter produced by agricultural waste burning. It is a major health concern in the northern region of the country, particularly in densely populated and industrialized NCR Delhi. It has become a top priority for the state and federal governments.



Shailesh *et al.* (2009)

Fig 4: MODIS Active fire locations over Indian Region



***Source*:** Jethva *et al.* (2016)

Fig 5: Smoke stream from crop residue burning in north west India (mainly Punjab and Haryana) towards low-lying regions of Delhi NCR in early November

It is clear from the figures that higher incidence of fires occurred over the IGP region, mainly in the Punjab and Haryana state followed by Uttar Pradesh, Madhya Pradesh and Maharashtra.

Table 1: End use of stubble by farmers in case of rice and wheat

End use	Rice (% of total stubble production)	Wheat (% of total stubble production)
Burnt	81	48
Fodder	7	45
Soil incorporation	1	<1
Rope making	4	0
Miscellaneous	7	7

Gupta *et al.* (2019)

2. Impacts of Crop Residue Burning

2.1 Impact of crop residue burning on environment

The main negative effects of burning crop residues include the emission of greenhouse gases (GHGs) that contribute to global warming, the increase in levels of particulate matter (PM) and smog that pose health risks, the loss of biodiversity on agricultural areas, and the decline in soil fertility. Burning crop residue considerably increases the amount of air pollutants such as CO_2, CO, NH_3, NO_X, SO_X, Non-methane hydrocarbon (NMHC), volatile organic compounds (VOCs), and semi volatile organic compounds (SVOCs), as well as particulate matter (PM). This is primarily responsible for the loss of organic carbon, nitrogen, and other nutrients that the soil would have otherwise kept.

Table 2: Major pollutants emitted during crop residue burning

Category	Pollutants	Source
Particulars	SPM (PM_{100})	Incomplete combustion of in organic material, particle on burnt soil
	RPM (PM_{10})	Condensation after combustion of gases and incomplete combustion of organic matter
	FPM ($PM_{2.5}$)	
Gases	CO	Incomplete combustion of organic matter
	NO_2	Oxidation of N_2 in air at high temperature
	N_2O	
	O_3	Secondary pollutant, form due to Nitrogen Oxide and Hydrocarbon
	CH_4	Incomplete combustion of organic matter

Singh *et al.* (2021) [11]

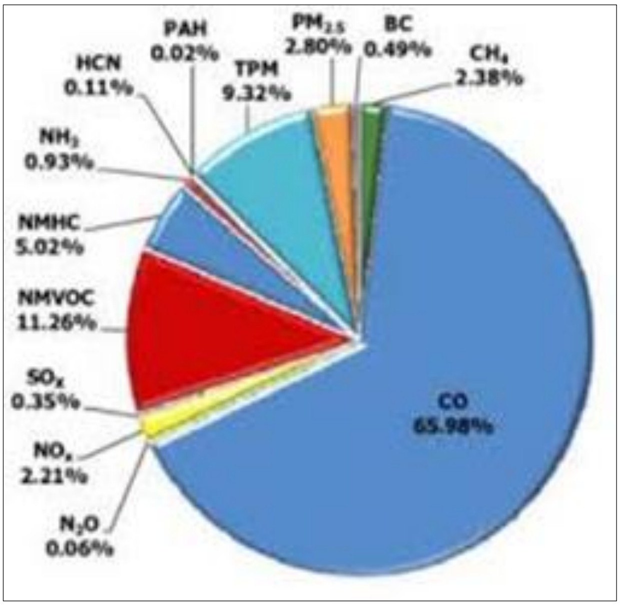


Fig 6: Contribution of different gasses from crop residue burning in India

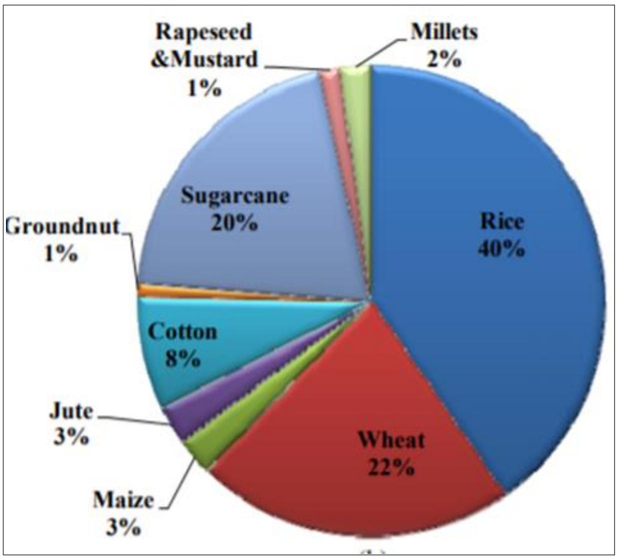


Fig 7: Contribution of different crops in from crop residue burning in India

Table 3: Greenhouse gas emission from Indian agriculture

Source	GWP (CO_2 eq)
Enteric fermentation	211
Manure management	27
Rice cultivation	68
Agricultural soil	94
Crop residue burning	6
Total	406

Gupta *et al*., 2019

2.1 Impact of crop residue burning on soil physical, biological & microbial activities

In addition to eradicating the pests and diseases associated with the stubbles and straw of previous crops, crop residue burning may boost mineralization for a brief period of time, resulting in a short-term increase in the amount of nutrients available to plants. Long-term fire reduces total nitrogen and carbon, as well as possibly mineralized nitrogen, in the 0-15 cm soil layer, as well as soil organic matter. Dhar *et al.* (2014) [3] found that wheat treated with rice straw and green manure had considerably greater levels of organic carbon, available nitrogen, available phosphorus, and available potassium compared to other treatments.

Burning crop residue raises the soil temperature to between 33.8 and 42.2ºC. Additionally, burning lowers the bacterial and fungal populations in the top 2.5 cm of soil. Even though the effect is transient, as bacteria regrow after a few days, frequent burning in a field may permanently reduce the microbial population. According to Chandra (2018) [1], the incorporation of rice residue at different crop growth periods had a substantial effect on the carbon content of microbial biomass. The highest microbial biomass carbon was recorded under rice stubble along with *Trichoderma* and Conventional tillage. Augmentation of microbial biomass Carbon may be attributable to a high supply of organic substrate during different stages of growth, but a sudden fall in microbial biomass may be attributable to a low availability of substrate during harvesting.

3. Strategies and technological interventions for Crop residue management

3.1 Incorporation of crop residues

Incorporation of crop residue into soil through adoption of conservation agriculture practices helps to prevent soil erosion from wind & water and to augment the soil moisture. In addition, crop residue incorporation also helps in reducing weed infestation. Khankhane *et al*. (2009) [6] reported that weed density and weed dry weight in residue incorporation treatment were on par with burning treatment. Dotaniya (2013) [4] reported that crop residue incorporated treatment recorded significantly higher yields of both rice and wheat and also higher nutrient uptakes in both the crops. This might be mainly attributed to microbial decomposition which converts crop residues easily into mineralizable form.

3.2 Composting

Promoting the use of crop residues for the creation of bio-enriched compost or vermicomposting and their usage as farm yard manure is one of the key strategies for reducing crop residue burning. In comparison to all other treatments, Phalke (2015) found that soybean seed yield, soybean protein content, maize grain yield, and maize starch content rose significantly in the treatment receiving in-situ recycling of sugarcane crop residues with press mud compost. Higher yields were attributable to the solubilization of carbon pools in press mud compost, which increased the availability of essential nutrients. Higher starch content in maize was also a result of higher K content in press mud compost.

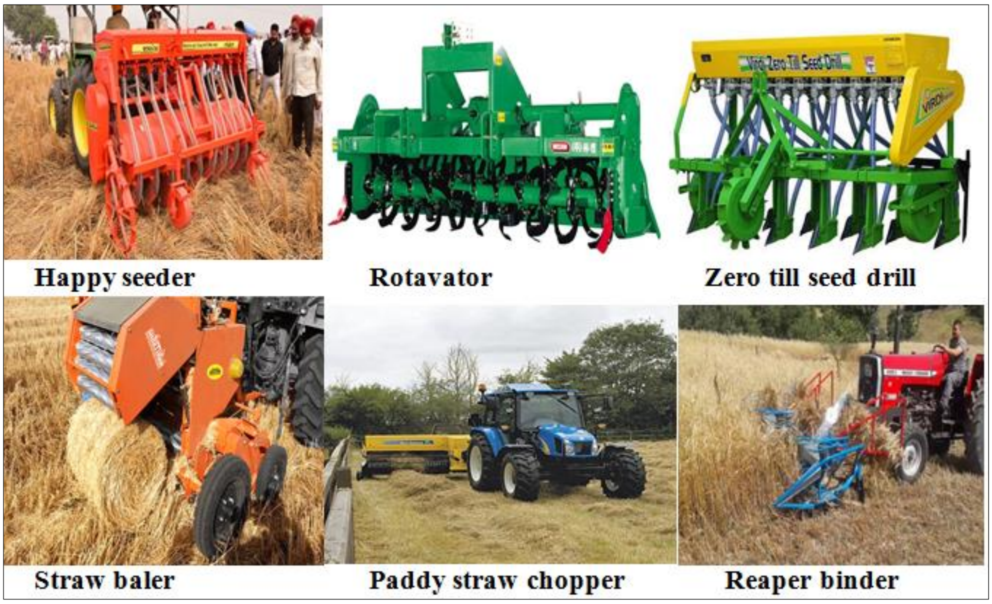
3.3 Bio char

Bio char is a fine-grained, carbon-rich, porous result of the thermochemical process pyrolysis, which occurs at low temperatures in the absence of oxygen. It consists of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S), and ash in variable proportions. When added to soil, extremely porous structure of bio char promotes water retention and surface area. It interacts primarily with the soil matrix, soil microbes, and plant roots, aids in nutrient retention, and initiates a vast array of biogeochemical processes. According to Coumaravel *et al.* (2015) [2] in Coimbatore, maize grain production was greatest with NPK + FYM @12.5 t ha^{-1} + Bio char @ 15 t ha^{-1} + Azospirillum @ 2 kg ha^{-1}, demonstrating that maize responded to bio char application when applied under IPNS. The reaction to bio char was most significant when treated with FYM and Azospirillum, followed by NPK alone. This could be attributed to the increased nutrient availability, which increased grain yield when bio char was sprayed with FYM + Azospirillum or NPK fertilizer.

3.4 Minimum tillage and Zero tillage
The term "minimum tillage" refers to the cultivation of a crop using only the tillage required for planting seeds at the correct depth and then covering them. The objective is to reduce tilling to the bare minimum required to ensure a good seedbed, rapid germination, adequate stands, and favorable growing conditions. Zero tillage refers to no tillage in which the crop is planted on unprepared soil by opening a narrow slot, trench, or band of adequate width and depth to ensure adequate seed coverage.

3.5 Crop diversification and alternate cropping systems
Crop rotation, crop diversification, and alternative farming techniques are crucial for preventing crop residue burning. The rice-yellow sarson-groundnut planting sequence had much greater grain yield and straw yield than the rice-wheat cropping sequence, but was statistically equivalent to the rice-vegetable pea-corn cropping series.

3.6 Mechanical intensification against crop residue burning: Utilization of agricultural machinery and equipment, such as the happy seeder, turbo seeder, rotovator, baling machines, zero-till seed drill, etc. to allow in-situ management of crop residue and retention of straw as surface mulching. Thind *et al.* (2014) [12] evaluated various establishing strategies and residue management approaches in rice and wheat and found that zero tillage- direct seeded rice was comparable to conventional tillage- direct seeded rice and transplanted rice. Singh *et al.* (2013) [10] observed in three districts of Patiala, Fatehgarh Sahib, and Kapurthala, Punjab, that grain production, straw yield of wheat, and economic indicators including gross returns, net returns, and BC ratio were significantly greater with happy seeder than with rotovator and farmer practice. It may be attributed to the increased number of tillers per plant and the length of the ear. Secondly, the presence of paddy straw on the surface of the soil may have increased the availability of moisture throughout the growing season. Due to a larger grain yield, this method of sowing produced greater gross returns than the inclusion technique. Happy seeder had a lower BC ratio than incorporation and the standard way of sowing as a result of its significantly lower cultivation costs.



4. Conclusion
It has been observed from the above research studies that *in situ* incorporation of crop residues can improve soil physicochemical and microbial properties which resulted in subsequent increase of yields. Bio char due to its stable nature can reduce CO_2 and other gaseous emissions by sequestering in to the soil. Crop diversification with residue management through organics can be advocated for increasing rice productivity, improving soil health profitability and conserving energy and Happy seeder technology not only saves time for sowing of next crop, but also results in higher profitability. Thus, it can take part in retaining soil health as well as environmental health.

5. Future line of work
There is a need to study on nutrient management in crop residue incorporation, assess the use of compost culture to enhance the decomposition of crop residues and more research has to conducted on natural farming technologies like use of crop residue as mulching and use of microbial consortia for enhancing decomposition and converting to humus etc.

6. References

1. Chandra R, Rana NS, Kumar S, Panwar GS. Effects of sugarcane residue and green manure practices in sugarcane-ratoon-wheat sequence on productivity, soil fertility and soil biological properties. Archives of Agronomy and Soil Science. 2008;54(6):651-664.
2. Coumaravel K, Santhi R, Maragatham S. Effect of bio char on yield and nutrient uptake by hybrid maize and on soil fertility. Indian Journal of Agricultural Research. 2015;49(2):185-188.
3. Dhar D, Datta A, Basak N, Paul N, Badole S, Terence Thomas. Residual effect of crop residues on growth, yield

attributes and soil properties of wheat under rice-wheat cropping system. Indian Journal of Agricultural Research. 2014;48(5):373-378.
4. Dotaniya ML. Impact of various crop residue management practices on nutrient uptake by rice-wheat cropping system. Current advances in agricultural sciences. 2013;5:269-271.
5. Jethva H, Chand D, Torres O, Gupta P, Lyapustin A, Patadia F. Agricultural Burning and Air Quality over Northern India: A Synergistic Analysis using NASA's A-train Satellite Data and Ground Measurements. Aerosol and Air Quality Research. 2018;18:1756-1773.
6. Khankhane PJ, Barman KK, Jay GV. Effect of rice residue management practices on weed density, wheat productivity and soil fertility in a swell-shrink soil. Indian Journal of Weed Science. 2009;41(1&2):41-45.
7. Ministry of New and Renewable Energy (MNRE). Annual Report, 2019–2020. In Energy; Ministry of New and Renewable Energy: New Delhi, India, 2019
8. Pathak H. Greenhouse Gas Emission from Indian Agriculture: Trends, Drivers and Mitigation Strategies. Proceedings of Indian National Science Academy. 2015;81(5):1139-1149.
9. Sanyogita Chaudhary. Influence of crop diversification and *in-situ* residue management using organics on rice performance (*Oryza sativa* L.) and soil health. *Ph.D. Thesis*, G.B. Pant University and Technology, Pantnagar, Uttarakhand. 2018.
10. Singh A, Kang JS, Kaur M. Planting of wheat with happy seeder and rotavator in rice stubbles. Indo American Journal of Agricultural and Veterinary Sciences. 2013;1(2):32-41.
11. Singh T, Ravindra K, Beig G. Influence of agricultural activities on atmospheric pollution during post-monsoon harvesting seasons at a rural location of Indo-Gangetic Plain. Science of the total environment. 2021;79(6):14-21.
12. Thind HS, Sharma S, Singh YS, Sindhu HS. Rice–wheat productivity and profitability with residue, tillage and green manure management. Nutrient cycling in Agroecosystems. 2019;113(2):10-16.