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In-Situ Crop Residue Management- A Review

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ABSTRACT

In-situ crop residue management is a challenge to the intensive agricultural systems which produce more food for the need of growing populations. More production of crops also produce large amount of residues, making difficult for the farmer to prepare land in a short time for the next crop. In order to clear the field the farmers opted for burning the residue, which is cheap, easy, economical and lest time consumed. Burning crop residue leads to air pollution, global climate change, soil health deterioration and increase soil erosion. Several greenhouse gases (GHGs) along with carbonaceous aerosols and particulate matter (PM)are the major source of air pollution also for the present global climate change. Global concern for certain diseasescause by air pollution due to burning of agricultural crop residue along with the fossil fuels is increasing which makes high immature mortality rate. So, different scientific community are in great concern for the management of agriculture crop residue. Burning of residue in surface of the soils also leads to deterioration of soil health, since soil is a living due to teeming microorganisms. Due to burning of residue, microbes are killed making soil unfertile. Also different micro as well as macro nutrients which are easily volatilised is loss due to burning of residue in the soil. So, it is of great concern to find an alternative management practices for the management of agriculture crop residue after harvesting. Only way to avoid the hazardous burning of crop residue is to find an alternative management practices. Those can be livestock feeding, residue retention in soil (conservation and conventional tillage), composting of the residue along with farm waste, biofuels (bio-oil and bio-char preparation from the residues) and using the residue for mulching.

Keywords: In-situ crop residue, air pollution, greenhouse gas, climate change

Introduction

For maintaining a sustainable agricultural productivity it is essential to recycle the nutrients from the crop residue after harvesting. For reducing air pollution and soil health improvement, one needs sustainable use of crop residue (Hou et al., 2019) after harvesting. In many parts of the world, agricultural residue burning is the most common practices followed for preparing land to cultivate the next crop (McCarty et al., 2017). Agricultural residue burning contributes around 8-11% of global annual fire (Korontzi et al., 2006). Burning agricultural crop residue can controls weed and reduce the risks of plant diseases and pest (Roy et al., 2008; McCarty et al., 2012). Although, it is the most common practices for its management but there lays certain negative impact on regional and global air quality (Vadrevu et al., 2011). In the recent global scenario, air pollution ranked highest for different disease leading to premature mortality especially in the developing country (Cohen et al., 2017). Burning agriculture residue which has been practices since time immemorial is the most common source of air pollution (Ravindra et al., 2019). Along with the fossil fuel burning, approximately 25% of the carbon dioxide evolve is concentrated in the terrestrial ecosystem which is need to be concern (Huntingford et al., 2017). Human induced activities like fossil fuel and agricultural residue burning has also greatly increased with a significant impact to the present global warming and climate change (Perkins- Kirkpatrick et al., 2017). Since time immemorial the only solution to the shortage of food is to increase the land holdings for agriculture food production (Licker et al., 2010). In the last 50 years the global food production has increase to double but the increase of land holding for agriculture is only by 9% (Pretty, 2008). With food demands for increasing population, intensive agriculture are practices around the globe leading to deterioration of soil and reducing the fertility. So, high input of fertilizer along with crop rotation is performing in many regions, which increase the

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crop production with high quantities of residue. Just after the harvest of the first crop, land should be clear for the second crop. The only convenient way to clear the field is through burning the residue which adversely affects human health, environment and climate (Ravindra et al., 2019). Agricultural crop residue burning emits certain pollutants along with different greenhouse gases (GHGs) in the atmosphere (Ravindra et al., 2019). It has a significant impact to the human health as well as modifies the chemistry of environment regionally as well as globally. So, there is need to concern the impact of crop residue burning which has been followed from time immemorial to safeguard the future population and global climate.

In densely populated region of India sustainable increased of crop production could play an important role for eradicating poverty and hunger by increasing farmers economic growth. Since the introduction of green revolution in 1960s, agricultural productivity in India increases with the used of improved variety, fertilizers and different new technology (Erenstein et al., 2008; Raza et al., 2019). So, with intensive agricultural practices the production rate increases with huge amount of crop residue after harvesting. For the preparation of field for next crop the easiest way to clear field is to burn the residue. In Asian countries crop residue burning accounts for 34% of all the biomass burned. Overall India accounts for 18% of the total residue burning of Asian countries (Streets et al., 2003; Taylor, 2010; Shaik et al., 2019). In the Indo Gangetic region of India around 24% of the crop generated after harvesting is burned in an open field making very poor air quality nearby (Ravindra et al., 2019; Ram et al., 2016; Pachauri et al., 2013).In this region rice-wheat system is the most important cropping system, producing large quantity of crop residues (Kang et al., 2009). Large amount of crop residue after harvest of the first crop remained in the field for a long time and management of this is a major challenge to the farmer (Naresh et al., 2017). In the year 2000, the total agricultural crop residue production in India was 347

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mt, and rice and wheat straw were accounted 57.64% of the total crop residue production (Singh and Panigrahy, 2009). Burning of agricultural crop residues increases the suspended particulate matter (SPM), aerosol loading, black carbon concentration, SO_2 and NO_2 in the atmosphere (Mittal et al., 2009; Kharol et al., 2012).Therefore it is of great importance to search an alternative management practices to utilized and discard the crop residue in a way that it won't affect the environment as well as the fertility of the soil (Setter et al., 2020).

Impact of crop residue burning

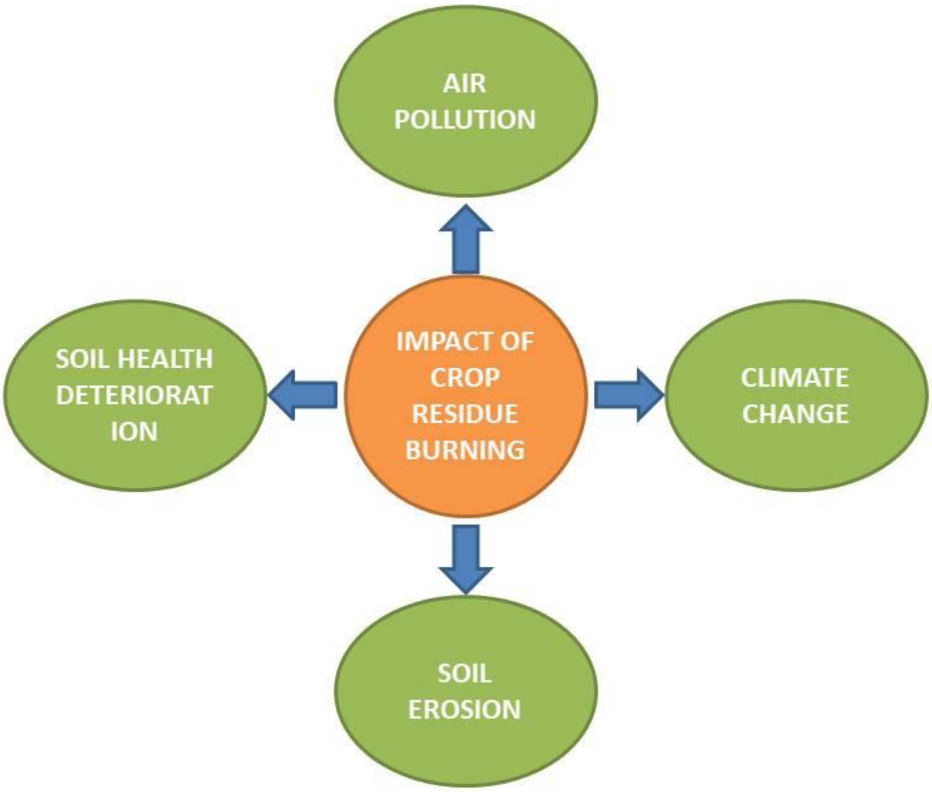

Fig. 1. Different impact of crop residue burning

Agricultural crop residue burning is a major source for air pollution, global climate change, soil health deterioration and soil erosion. Carbonaceous aerosols which are produced during the burning of crop residue play an important role for both global climate change and air pollution (Jethva et al., 2018; Shaik et al., 2019). Carbonaceous particle present in the air has

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drawn increasing attention by different scientific community due to hazardous affect in human health. An alarming situation has reached for air pollution,which is a global burden of human disease resulting premature mortality. Certain particulate matter (PM), trace gases, volatile organic compounds and greenhouses gases leads to deteriorate the human health when inhaled them (Ravindra et al., 2019). Due to increase in global population and the need of food, the intensity, frequency and distribution of residue burning has increased during the last 100 years (Vadrevu and Lasko, 2015). The production of different GHGs like NO_2, SO_2, CO, CO_3 and different carbonaceous material in the atmosphere leads to influence/ change the chemistry of troposphere and stratosphere leading to the earth's climate change (Shaik et al., 2019). The carbonaceous material associated with strong light absorption largely responsible for positive radiated forcing leading to higher temperature to the atmosphere (Tang et al., 2013).

Soil is considered as living with important ecological factors like soil temperature, structure, air, and its correlations with the climate and atmosphere (Butnariu, 2012). In situ crop residue burning in the surface of the soil leads to the degradation of soil physical, chemical and biological properties. But, such change depends on how long it has been burning, its intensity, moisture, types of soil and climatic conditions (Pietiikainen and Fritze, 1995). Certain valuable nutrients especially which are easily volatalizable nutrients like Nitrogen (N) and Sulphur (S) are lost due to the residue burning. Crop residue burning also affects the organic matter content in soil and loss of valuable carbon and energy rich residue takes place (Grover et al., 2015; Bishnoi, et al., 2011). Different microorganisms present in the soil are killed due to high temperature from the residue burning, which affects the biochemical properties i.e. activities of soil enzymes (Kaur et al., 2019). Due to removal of crop residue by burning from the surface soil, the erosion (both air and water) increases. Severe fires can increased soil bulk density and reduced soil porosity which in turn reduce the soil

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permeability (infiltration rate and hydraulic conductivity) leading to severe soil erosion. When fire exposes the soils, no vegetation are there to withstand the impact of raindrops on bare soil that can disperse soil aggregates and clogs pores, ultimately reducing soil porosity (Wilcox et al., 2003; Shakesby and Doerr, 2006).

Crop residue Management

Large amount of residue from the harvesting of crops need to be discarded soon for preparation for next crop. Due to high population, demand of food is increasing day by day. So, to feed the increasing population, production of foods can be increase with increasing productivity of the field. Intensive agricultural practice produce large amount of crop residues. To manage this residue other than burning of it, certain scientific community has suggested the following management practices (Figure 2) which will decrease the environmental pollution and global climate change. It will also improve the health of the soil, resulting more crop production as well as dairy farm production.

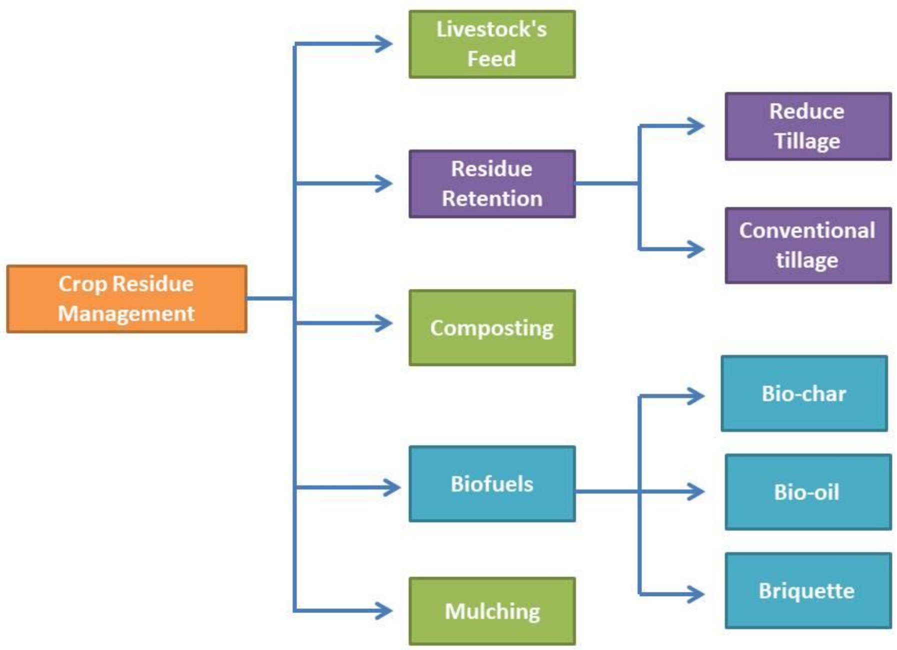

Fig. 2. Different agricultural crop residue management

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Livestock's Feed

Crop residues after harvesting are traditionally utilized as animal feed solely or in combination with certain supplements. Utilization of agricultural crop residue by feeding to the livestock/cattle can be one way to manage it. In dairy farm industry, feed accounts for the largest parts of operating cost. If crop residues that are coming from the field, be transported to dairy industry as a feed to cattle, than the major problem faced by farmers to manage can reduce to some extent. Improving feed efficiency of dairy cattle from the residue obtained from crop harvesting can increase farm profitability vis-à-vis reduce the environmental pollution. For management of crop residue, burning is commonly practiced by farmers to get rid of the residue after harvesting, of its cheap, convenient, economical and easy methods for managing in situ crop residue, burning residue is commonly practiced. Another reason can be of time saving by burning, as the farmers have to clear the field preparing for next cropping (Kaur et al., 2019). So, to reduce the health hazard effect by burning the crop residue, it is better to feed the cattle with the residue after harvesting. This will give both benefits to the dairy farming as well as reduce the air pollution which can cause by burning the crop residue.

Residue Retention

As soon as the farmers harvest the crop, the main problem faced is the management of crop residue (the crop that is cut but not harvested). One of the practices followed by the farmers is the retention of residues to the field itself, which will promote the OM present in the soil resulting with the improvement of different physical conditions of soil (Hiel et al., 2018). For *in-situ* residue retention, the farmers can follow reduce tillage or conservation tillage and conventional tillage. For soil organic matter (SOM) stabilization processes, tillage can be an important factor by influencing residue decomposition rates, which ultimately affect the distribution of C and N across SOM fractions (Grandy and Robertson, 2007). But the positive

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effect of tillage varies with the extent and nature of physical manipulation (depth, intensity and frequency) they cause (Reicosky, 2015). Appropriate tillage practices avoid the deterioration of physical, chemical and biological properties of soil maintaining sustainable crop production (Lal 1981). Reduced tillage (conservation tillage) practices improve the physical, chemical and biological properties of soil by enhancing the retention of residue, reducing the physical disturbance of soil, which will allow more accumulation of SOM (Lal and Kimble, 1997). Reduced tillage provides the best way for reducing SOM degradation ultimately improving water retentionand soil productivity (Parr et al. 2014). Reduce tillage is a soil conservation practices in which the plant residues from the harvested plant parts should at least cover 30% of the surface soil which is mainly to improve the physical, chemical and biological properties of the soil with an aim to reduce the soil erosion through wind and water. Nowadays, reduce tillage is been increasing interest of its effectiveness for controlling soil erosion of different regions (semi-arid and sub-humid) (Unger and McCalla, 1980). Conventional tillage on the other hand includes both primary (mouldboard ploughing) and secondary tillage operation(disking and/ or harrowing) which aims at reversing and stirring a deep layer of soil incorporating the residues present in the soil (Blevins and Frye, 1993). Conventional tillage increase the aeration of the soil vis-a-vis exposed the soil to the sun which reduces the pest and weeds infestation. Due to mixing of crop residues and increase aeration of soil the decomposition process speed up leading to the reduction of the crop residue present in the soil. No doubt that in conventional tillage due to fast decomposition of SOM, erosion of the soil may increase but for crop residue management, conventional tillage has more advantages than the reduce tillage.

Composting

The recycling of excess crop residue after harvesting by composting is one of the management practices for controlling the excess residue after harvesting. If crop residues are

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managed properly than it is not a waste to the farmer but a resource for soil health. Crop residues are source of certain nutrients (Av N, P, K and S) and also the primary source of OM in the soil. In different region of the globe, there is little recycle of the crop residue in the field instead they burned it or make as a waste due to lack of knowledge or lack of technology (Tesfaye et al., 2011).Various forms of farm waste can be converted into useful products by composting for nutrients requirement of crop besides the residue management.Composting is the natural decomposition of organic materials or crop residues along with the farm waste, animal waste and vegetable waste with the help of microorganisms present in the soil. After harvesting of crops the bulk amount of residues can be converted into small quantity or reduce the bulkiness by composting process. In completion of composting, the compost material can be used as a natural fertilizer as a source of different macro and micro nutrients. This natural organic fertilizer in soil can improve the physical, chemical and biological properties of soil. Different types of composting (aerobic, anaerobic and vermicomposting) can be used to reduce the bulk amount of crop residue in the field itself (Sidhu and Beri, 2008). So, another important management of agriculture crop residue is composting. That converts large quantity of residue materials into small bulkiness, possessing certain soil health benefit and improving soil physical, chemical and biological properties.

Biofuels

The continuous growth of population with economic development needs food and energy. So, there is a need to increase the food grain production which will provide both food and energy. Numerous wastes are abundantly available around the world as an agricultural crop residue that needs some management strategies. Currently for energy source 80% of the world need is depend entirely on the fossil fuels (Barros et al., 2018). Using such non-renewable sources of energy will leads to environmental degradation and pollution by releasing different harmful gases to the atmosphere (Setter et al., 2020). Different agricultural crop residues are lignocellulosic containing carbon in nature, which is the main source of renewable energyalternating the fossil fuels (Leng et al., 2018). So, the crop residue which is rich with lignocellulosic materials can be used as an alternative source of energy as biofuels and has the potential to reduce the global greenhouse gas emission.

Different lose agricultural residue can be managed by converting into densified solid biofuels through briquetting technology (Werther et al., 2000). Briquetting is a process where the harvested crop residue is compacted densely allowing the replacement of wood as fuels (Setter et al., 2020). By densification of crop residue through briquetting, it is easier for the agricultural waste to transport, store, and use as a biofuels.

Other than densification of crop residue the most commonly used technology for management of residue is pyrolysis (thermal decomposition of residues at elevated temperature in an inert atmosphere). Pyrolysis technology can convert the crop residue into solid (biochar), liquid (biofuels) and gas, reducing the bulkiness of the agricultural residue. The liquid fraction of pyrolysis is an important biofuels for energy source and heat generation and also it is mainly used in many pharmaceutical companies. The solid fraction is biochar which is gaining much attention due to its favourable role in improving soil properties and environmental management issues (Lehmann and Rondon, 2006). Its substantial effect on reducing global warming, increasing atmospheric carbon sequestration and improving soil properties, its application in agriculture is very important (Qambrani et al., 2017).

Mulching

Different crop residues can be collected from the field after harvesting and used as mulch, for growing other crops. This will increased the water retention capacity of soil and maintained the soil temperature for proper plant growth. Covering the soil through mulching will

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suppress the weeds growth throughout the entire crop season for the main crop (Mirsky et al. 2013). Small seeded annual weeds will be suppressed by mulching the soil with residues from crop harvesting without affecting small grain seedlings with the concomitant increase of the production of the main crop (Nichols et al. 2015). Different scientist (Altieri et al. 2011; Robb et al. 2018) have studied the effect of organic mulching in vegetable crop production (Vincent-Caboudet al., 2019). For vegetable crop production, one of the most important advantages of crop residue mulching is reduced incidence of soil-borne diseases. Organic residue mulching produce high amount of biomass with higher carbon: nitrogen ratio making very slow residue decomposition which provides long term soil coverage for weed suppression (Mirsky et al. 2012). Organic residues have the ability of winter hardiness and can result in immobilization of available N in the soil resulting continuous weed suppression (Clark et al. 2017).

Conclusion

The unwanted agricultural crop residues after harvesting are burnt to clear the field as a preparation for the next crop. Since burning residue is the cheapest, less time consuming and economical as compared to other methods using different machines. Burning of residues not only affect the soil health but also it is mostly concern for the on-going air pollution and global warming. Since, burning crop residues produce certain carbonaceous materials, gases like NO_2, SO_2, and many greenhouse gases. So, it is of great concern to manage the residues in a sustainable manner, so that there will not be any negative effect to the soil as well as to atmosphere. So, to avoid the burning of crop residue, certain alternative management practices should follow. Among them the most suitable management practices are livestock feed, residue retention (both conservation and conventional tillage), composting, biofuels (Biochar preparation and bio oils) and mulching.

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