# Sustainable agriculture and Stubble Burning approaches: A step towards clean environment

Ankur Omer[1], Anamika Singh[2]
[1]*Government College Silodi, Katni, Madhya Pradesh*
[2]*Department of Botany, Maitreyi College, University of Delhi, New Delhi*

***Abstract*** **- Whole north India vegetation is dominated by two major crops, Wheat and Rice. Gujarat, Punjab and Uttar Pradesh are well known for the production and these states are also facing issues related to the leftovers of rice cultivation that is 'stubble'. The most common and easy practice is that farmers usually burn it in order to clear the land for the next crop. Recent years this practice was taken into serious considerations, as this conventional practice of stubble burning has been a major cause for pollution in Delhi and its neighbouring cities. There are many alternative practices to overcome this issue, but the most important is awareness among farmers and government support. Our article is based on the novel approaches of stubble utilization for sustainable agriculture, use of these methods in positives ways for some useful productions as well as minimization of pollution. Some important stubble uses are rice Residue as Fodder for animals, mushroom cultivation, paper production, biogas productions and Bio-oil generation from unwanted agricultural wastes. Few organisations are working in these areas like Punjab Agriculture University (PAU) in collaboration with Australian centre for International Agricultural Research (ACIAR) has taken an initiative for in-site management of paddy stubble. They developed a machine called 'HAPPY SEEDER', is a machine that is mounted on the tractor cuts and lifts rice straw, sows wheat into the soil then mulches the sowed area with the straw. Although science and technology is expanding day by day and but the awareness, approaches towards environment safety and utilization of agriculture wastes is now a priority for a healthy Earth. Creating awareness among farmers at grassroots level is very important for their personal gain as well as for the betterment of environment.**

***Index Terms*** **- Stubble, Air pollution, Agriculture waste, Pollution, happy seeder.**

## INTRODUCTION

Last few decades have witnessed enormous increase in the demand of food supply throughout the world especially in developing countries such as India. India shares around 2.4% geographical area of the world but supports 17.6% of world's population depicting the pressure on its natural resources to sustain the need for such a large population [1]. The agricultural industry is the prime sector playing major role in world economy. India is the second largest agriculture based economy where annual crop cultivation, produces a massive amount of agricultural related waste (including crop residues) [2].

Figure 1 compares the agricultural wastes generated by some selected Asian Countries. India accounts for much larger production of agricultural wastes than the aggregate waste production by the other countries of the region. Indian Ministry of New and Renewable Energy (MNRE) estimated that India generates on an average 500 MT (million ton) of crop residue each year [1].

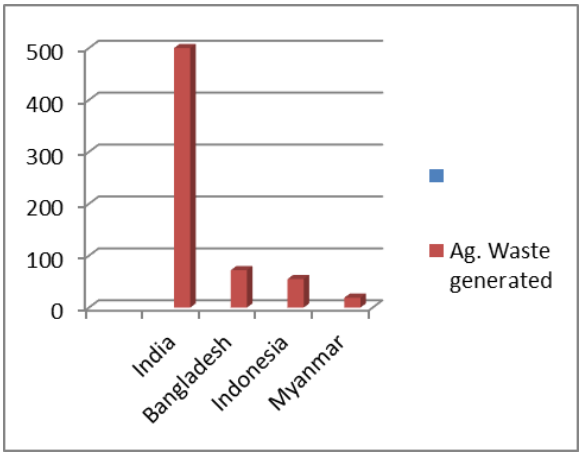


Figure 1: Production of agricultural waste in India: figure showing comparison of other selected nations in the same region

The Agricultural waste so produced can be utilised in a number of applications. However, in a developing country like India the cost of collecting, transporting and processing the wastes can be significantly higher than the overall income generated as a result of such waste being put to good use [2].

This topic needs more attention, wider audience and is not limited to any specific region as the agriculture waste generation is global issue and efficient utilization of agri-wastes can provide various benefits to the society [3].

Crop residue refers to the plant material left over after harvesting, such as leaves, stalks, and roots [4]. Although, crop residue is a natural resource that can contribute to enhance the stability and fertility of soil but increased demand has lead to large scale production. From Farmer's perspective they prefer onsite burning possibly due to following reasons like 1) eagerness to quickly prepare land for next cycle 2) shortage of time between the harvesting and sowing time of next crop [5-6]. The traditional and efficient method of crop residue management have certain practical limitations which forces farmers of developing countries especially in Asia like India to burn the surplus residue. In India the residue generation and stubble burning is highest in Uttar Pradesh, and then followed by Punjab (Figure 2), while according to Indian Agricultural Research Institute (IARI) around 14 Mt out of 22 Mt rice stubble (about 63.6%) is burnt each year [7].

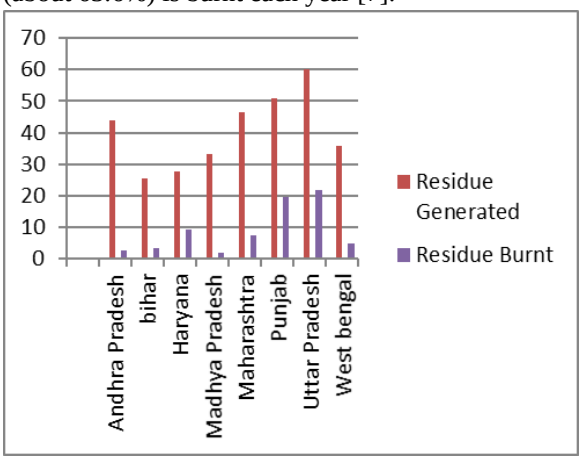


Figure 2: Crop residue generated and burnt in major states [1].

The nonfood based chunks such as stalks, husk, straw are lingo-cellulosic biomass, Compared to other constituents lignin shows high resistance to degradation.

Stubble burning is major contributors (being 3rd after industrial and vehicular emissions) to atmospheric pollution having severe health effects on environment and human health [5, 8-9].

Each year witness a harsh haze during winter season over south Asian region which is associated with the stubble burning periods [10-11]. During winter atmospheric inversion, poorer dispersion and lower rate of smoke dispersion provides higher residing time for air pollutants. As a result, the smoke produced builds up in the atmosphere, causing further harm [12].

In India according to global air quality report 14 out of 20 world's most polluted cities are from India, most contaminated being the Ghaziabad of Uttar Pradesh. Delhi has been named one of the world's most polluted cities since 1990 due to the numerous human activities that created fog and haze [13].

## EFFECTS OF STUBBLE BURNING

### Air Quality

The burning of stubble poses a major danger to the exposed environment's air quality. According to Kaskaoutis et al. (2014), agricultural burning has a significant impact on air quality due to the release of aerosols and gaseous pollutants [14]. PM 2.5 and PM 10 are said to have the greatest impact on the health of those who are exposed. A source apportionment analysis was done by the World Bank in 2001. (1st of its kind) on PM 2.5 for several Indian cities. In metropolitan cities such as Mumbai, Delhi, Chandigarh, and Kolkata, biomass burning contributes 9-28 percent, 23-29 percent, 24 percent, and 37-70 percent to PM 2.5 concentrations, respectively. During the rice and wheat stubble burning periods in 2011, PM2.5 concentrations in Delhi surged by 78 percent and 43 percent [15].

While comparing burning and non-burning events Singh (2015) reported a 300 mg/m3 rise in the hourly concentration of PM 10 during burning events in Delhi. Mandi-Gobindgarh, Punjab in 2015 witnessed increase in PM 10 and PM 2.5 concentrations by 86.7 % and 53.2 % for rice and wheat seasons [16]. In November of each year, the air quality in the north Indian states deteriorates. On account of existing accumulated pollutants from automobile industry, stubble burning emissions have a greater impact on air quality in metropolitan areas, resulting in poor air quality conditions [17]. Air Quality Index (AQI) is the

parameter used to represent the air quality of a region on a categorical range of 0-500.

Most North Indian regions have a higher AQI level that is beyond acceptable range, especially during burning events. According to Kapil et al AQI in November 2019 of Delhi had a peak of 487, Ghaziabad with 493, and Greater Noida with 480. As per CPCB these AQI peak values falls in severe category. As a result, the governments of Delhi and other northern states closed elementary schools and urged residents against participating in early morning outdoor activities [18].

Soil fertility

Aside from the negative impacts on air quality, stubble burning reduces soil yield by destroying key minerals [19]. It boosts soil temperature making it inhabitable for key microorganisms at a depth of around 2.5 cm [20]. This results in an added cost of restoring soil fertility by fertiliser or compost application. Stubble burning results in the depletion of Nitrogen, Phosphorus, and Potassium (NPK) and other vital micro-nutrients. For example rice stubble burning results into the loss of around 0.445 Mt of NPK, wheat stubble burning leads to loss of around 0.144 Mt of NPK, and sugarcane stubble burning leads to loss of around 0.84 Mt of NPK [20].

Agricultural productivity

There is convincing evidence suggesting affect of pollution directly or indirectly on agricultural sector. Sulphur and nitrogen oxides may combine with water to form acid rain which shows severe effect on plant and their parts and may result in plant death [21]. Chlorosis may also result due to prolonged exposure of plants with particulate pollution [22]. Nitrogen oxides and volatile organic compounds released due to stubble burning may react to form ground level ozone in the presence of solar radiations. This ozone may affect plant metabolism showing severe effects on crops in northern India [23]. Therefore, with the increasing food demand this negative affect due to stubble burning needs to be dealt immediately and effectively.

Human health and wellbeing

Several researches have also linked the negative effect of air pollution on human health. Some cases may result into severe health conditions or may lead to lethality especially in the person with pre-existing respiratory problems [24]. Permanent health injuries like emphysema, Chronic Obstructive Pulmonary Disease (COPD), bronchitis cancer etc may also result in some chronic conditions. Recent years have witnessed the gradual increase in the death rate due to air pollution. For example, south asia have witnessed an increase in death rate from 1.1 million to 1.2 million between 1990 and 2015 [23]. In India around 6 lakhs people dies prematurely every year. Ghude et al in 2019 reported a decrease in the life expectancy of the people living in Delhi by around 6.4 years [25-26]. In neighbouring nation Pakistan also air pollution is one of the leading cause of death and around 135,000 people dies every year.

The economic development

Air pollution has been linked to a drop in the nation's total GDP, according to many studies. According to Ghosh et al., India's economy was affected by air pollution by 4.5 to 7.7% of GDP in 2018 and the proportion increased to almost 15% when forecasted to 2060 [22-23]. According to the World Bank report, air pollution cost the global economy by around $225 billion in 2013, with the majority of the cost coming from developing nations [27]. Apart from this air pollution may have impact on tourism sector for example Delhi has witnessed decrease in tourists visit in recent years by about 25-30% [28].

Looking beyond stubble burning

Majority of the farmers of the northern states of India like Punjab, Uttar Pradesh and Haryana grow only two crops a year-Rice and Wheat. The time period between the rice harvesting and wheat sowing is less than 20-25 days. Major water requirement of paddy is met through monsoon rains (june/july - october/november) and soon after its cultivation wheat is sown (November/December -March/April). The easiest, time efficient and cost friendly method for farmers to clear the field is to burn the stubble. Around 23 million Tonnes of stubble is burned every year in India, which results in the sharp spike in the air pollution index of nearby cities like Delhi, Gurgaon etc. Adopting greener alternatives for such practices is of utmost priority for both central and state governments.

1. In recent years the use of Happy Seeder, a tractor mount machine has been one of the most promising alternatives to the traditional method of burning the

crop residue. Happy Seeder also known as Turbo Happy seeder is tractor wielded machine developed by Punjab Agricultural University in collaboration with Australian Centre for International Agricultural Research (ACIAR), for in-situ management of paddy stubble (straw). It works on the principle of No Tillage. It is a multi-unit machine with combined harvester, straw management system and no tillage drill. With the help of this machine the rice crop residue can be chopped off and removed from the soil, wheat seeds then can be sown directly into the soil without tillage and then the residue is spread all over the field as mulch. The yield of crops sown using this technology is either higher or similar to crops grown by conventional method [29]. Happy seeder-based farming method turned out to be most profitable and expansive technique by giving an average of 10-20% more profit than burning and reducing the greenhouse gas emission by 78% [30]. Zero tillage policy improves the soil quality, less water consumption and a 90 kilogram-per-hectare reduction in greenhouse gas emissions [30].

2. Bio Decomposer: Indian Agricultural research Institute (IARI), Pusa, New Delhi has come up with an innovative idea to stop the practice of crop stubble burning. They have designed a capsule containing various Fungi developed by scientists at IARI. This capsule is capable of degrading 90% of the rice straw. Farmers have to chop the residue, spread it all over the field and spray the solution evenly. The field is then left for 25 days after irrigation. The trial run for this bio decomposer has been done in the fields of Delhi and other neighboring states and the results are very promising [31].

3. Bio Compost: According to recent estimation around 50 % of the Indian agricultural waste is produced by crops like Rice, Wheat, Oil seed. These crop residues are store house of significant amount of mineral content, around 6.5 million Tonnes, which is almost 30% of total NPK consumption of India. Recycling these crop residues into Bio-compost by using microbial consortia and other organic compounds like amino acids, Phyto stimulants etc. can be very useful in improving soil and plant health. Commercializing this practice can provide a stable livelihood to our rural community. After taking into consideration all the parameters, different studies were conducted on soil characteristics post bio compost application. It was found that Bio compost not only enriches the soil nutrients regularly but also minimizes the dependency on chemical fertilizers [32-33].

4. Packaging: Around 43% of the plastics made in India are used for packaging purposes and a large amount of them is single use plastic. Annually, around 9.46 million tones of plastic waste is generated in India and 40% of it remains uncollected. The improper plastic waste management has resulted in the release of many toxic and harmful chemicals in air, water and land. A vast majority of aquatic as well as human lives have been severely affected by the plastic waste. Biodegradable packaging is the most sustainable solution to this problem and the recent advancement in this process is the use of agricultural waste. Rice straw management has always been challenging to farmers, therefore, utilizing crop residue for packaging purpose can be our one stop solution to many problems. Paddy residue can be chemically processed to make paper and cardboard. This can significantly curb the demand of single use plastics. This practice will help in managing paddy straw efficiently and will also improve the economic status of farmers [33].

5. Briquetting: Briquettes can be made out of the biomass which are of regular shape but comparatively easier to use, appropriate to transport, and hassle free storage. Straw briquettes have a high latency of being used in industrial boilers, gasification furnaces, heaters, hot water boilers. It can be a good replacement for furnace oil, direct wood or coal. The rice straw can be used as a greener alternative to coal in thermal power plants [33].

6. Pelletisation: The biomass can be scrunched into 20-40 mm long tablets with 6-8 mm diameter. These pellets have probable use as fuel in stoves, heating machines in the domestic sector and industries. It can act as a good alternative for coal or direct wood when used in an appropriately designed cookstove for the purpose. It can be used in mass cooking purposes like in open kitchens, social gatherings, get together, etc [33-34]..

7. BioCNG: The chopped paddy straw can be digested using a variety of microorganisms and produce Bio fuel which is further purified and compressed to give BioCNG. It has a great potential to be used as a fuel in industries and automobile sectors.The process of Bio-CNG production has mainly four steps:extraction, purification, pressurizing and storage and dispersion. In extraction step, biogas is produced through a process in a single–stage reactor from biomass. The

main components of Biogas are:methane (CH4), carbon dioxide (CO2) and hydrogen sulfide (H2S). In the next step,all unwanted gas is removed from the Biogas and the purified product forms BioCNG. Bio-CNG is almost similar to the commercially available natural gas. In next step, the purified biomethane is pressurized and stored in certified high-pressure cylinders .BioCNG thus collected is ready to be supplied for use in cooking and housing power supply as well as automobile vehicles [33][35].

8. Dry fermentation biogas plant: One of the government-approved process for paddy straw management is anaerobic digestion of the residue. In this process organic matter is degraded in the absence of oxygen by the action of some micro organism. Methane (CH4), carbon dioxide (CO2) with small quantities of water vapor (H2O(g)), hydrogen sulfide (H2S) and ammonia (NH3), are the main components of the biogas. The process of Anaerobic digestion can be explained in four stages: 1) hydrolysis, 2) acidogenesis, 3) acetogenesis, and 4) methanogenesis. Since carbon present in organic matter is released in the form of CH4 and CO2 , the C/N ratio (carbon/nitrogen) of the remaining digestate reduces. Also, the availability of Nitrogen is increased during the process, as Nitrogen bound in organic matter is converted into ammonium (NH4+) ion which is readily available to the plants for direct use. Depending on the capacity of the processor, a fully loaded digester can produce sufficient gas for 3-4 months. The sludge formed in the process is a good quality manure and can be used in fields. The gas can compensate for 4 cylinders of LPG per month. 5 such plants are running successfully at The Punjab Agriculture University. Installation of such plants near the villages can significantly reduce the dependency on coal, wood and other gases for cooking purposes [33][36].

9. BioPower: As the energy demand is increasing exponentially with time, the need for newer energy source is more than ever. Our dependency on the fossil fuels as the source of energy has resulted in the gradual depletion of these resources. Also these fuels have been one of the major contributors of greenhouse gases in the environment. As we know rice is the staple diet of the people in South Asia, therefore, there have been tremendous rises in the number of paddy fields in the region. With this increase, the crop residue management has become a major concern for the authorities. The traditional method of burning the straw contributes heavily to the pollution and green house gases emission. In past few years many studies have been conducted to develop a greener alternative to residue burning, harnessing electricity is one of them. Energy can be harnessed from paddy straw in a biopower plant. Punjab has already initiated the project of setting up of such plants. This technique would discourage the common practice of burning the stubble among the farmers. The ash produced in the process as a byproduct can be used to make roads [33] [37-38].

10. Biochar: By pyrolysis in a brick kiln, paddy straw may be converted into Biochar, which is equivalent to activated carbon. This biochar may be used to manufacture renewable intense sticks, deodorizers, and fertilizers for gardens, among other things. It also improves the quality of the soil by increasing the carbon content [33].

## SUMMARY AND CONCLUSIONS

Increased demand, mechanization of farming practices, adoption of newly developed irrigation strategies, and utilisation of agrochemicals has raised agricultural wastes. Haryana, Uttar Pradesh and Punjab are amongst the major wheat and rice producing states and therefore a large number of agricultural wastes are produced. These states remain the major contributor in Burning of agricultural wastes and thus shares higher percentage in their contribution towards the addition of gaseous pollutants and hence increasing air pollution to the atmosphere. The management of such a vast amount of agriculture related waste is a great challenge in many countries especially in developing countries such as India. Crop residue is one of the agricultural wastes produced from major staples of India, Rice and Wheat posing problem in their management as large scale cultivation of these crops is necessary to accomplish the demand of ever-expanding population.

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