Indian Farmer
Volume 9, Issue 03, 2022, Pp. 104-108.
Available online at: www.indianfarmer.net
ISSN: 2394-1227 (Online)

ORIGINAL PAPER

Stubble burning effect on Agriculture, Environment and humans

Jatinder Kaur and Gursewak Singh

Department of Climate Change and Agricultural Meteorology
College of Agriculture, Punjab Agricultural University, Ludhiana

Corresponding author: jkbrar7@gmail.com

Article Received: 14 March 2022 *Published Date: 17 March 2022*

ABSTRACT

Stubble burning is major contributors of air pollution and it is a main source of gaseous pollutants such as, carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), and methane (CH_4) as well as particulate matters which causing serious damage to human health and the environment. In India Rice-Wheat cropping system adopted which generates large amount of stubble. In India 352 MT of stubble generated each year out of which 22% contributed by wheat and 34% by rice crop and out of this 84 Mt (23.86%) is burnt on field every year after harvesting of crops. Air pollution causes severe problems like skin and eyes irritation, cardiovascular and respiratory diseases, asthma, chronic obstructive pulmonary disease (COPD), bronchitis, lung capacity loss, emphysema, cancer, etc. In addition to its effects on air quality, stubble burning also disturbs soil fertility (through the destruction of its nutrients), economic development and climate. Today, it becomes necessary to aware the farmers about the availability of economically viable options and the multiple effects of stubble burning.

Key Words: Stubble burning, Pollution, Agriculture, Health Problems

INTRODUCTION

Rice-Wheat rotation system is the common farming system in the Indo-Gangetic Plain (IGP). The IGP is an important region located in South Asia blessed with fertile

agricultural farmlands and a diverse ecosystem. This region provides 41% of the annual food production in India most of which are grains. Out of approximately 66 million hectares (total area of the IGP), about 12 million hectares are utilized for the wheat-rice (Crop rotation) production system. An estimated 9.6 million hectares of land are utilized annually for the rice-wheat cropping system in India.

The use of Combine harvesters for harvesting grains is common among Indian farmers especially in the northern parts of the country. This machine can combine three different tasks, i.e. Reaping, Threshing, and Winnowing into a single operation. They are reported to be efficient in harvesting different types of grains, however; they generate a huge amount of stubble consisting of tall stalks, about 15 cm high, which are difficult to be incorporated into the soil. A significant amount of the stubble generated is set to fire on the field. According to the Indian Agricultural Research Institute (IARI, 2012), approximately 14 million tons (Mt) out of the 22 Mt of the rice stubble (about 63.6%) generated each year in India is set to fire. Haryana and Punjab, two of the key agricultural states of India, alone contribute 48% to this amount. In the Punjab region, rice and wheat account for about 85.91% of the total cultivation with other crops produced in relatively minor quantities.

The impact of stubble burning is more severe during the rice stubble burning season as the lower winter temperature leads to a more stable atmosphere. The fact that pollutants stay longer in the atmosphere during this time, and that the amount of rice stubble burned is quite higher than that of wheat results in a harsh level of pollution often obstructing visibility. The atmospheric inversion provides greater residing time for pollutants, poorer dispersion, and lesser rate of smoke diffusion. The smoke generated, therefore, accumulates in the atmosphere exerting more damage to the environment.

It is worth noting that stubble burning is not the only cause of post- monsoon deteriorated air across the IGP; meteorological conditions such as ambient temperature, relative humidity, wind speed, wind direction and ambient pressure also play important roles. The post-monsoon meteorological conditions favor more stable atmosphere rendering the pollutants to accumulate and reside longer in the atmosphere leading to severe levels of pollution. Air pollution poses a serious threat to human health and wellbeing leading to a rise in mortality and disease rates in many parts of the world. According to WHO, toxic air, as a result of pollution, results in the death of about 7 million people in the world annually.

The impact of stubble burning may increase in the coming years with the increase in population and food demand. A report by the United Nation pointed out that the world population may rise to 10 billion by 2050, which will in turn lead to increased food demand. In India, crop production is projected to increase by 45% by 2050, i.e. from 619 Mt (million tons) in 2017 to 899 Mt in 2050. This will necessitate the production of more food and consequently the generation and burning of more stubble.

Several efforts have been made by the government to provide alternative management techniques for the farmers to manage their crop stubble. Despite strict policies, the practice of outdoor crop stubble burning in India continues to be a threat to human health and wellbeing. However, in 2018, the Ministry of Environment, Forest and Climate Change (MoEF and CC), Government of India, reported a reduction in the number of stubble fires in Haryana and Punjab by about 38.93% and 20.3% respectively as compared to 2016. Many regions in the North including Punjab have banned this practice through their state pollution control boards since 2005. However, satellite fire hotspot data have shown an increased occurrence of agricultural fires through the subsequent years and observed the continuous occurrence of fire in about 60% of the total agricultural areas in Punjab and Haryana.

EFFECT OF STUBBLE BURNING

Effect on air quality

Burning of stubble poses a serious threat to the air quality of the exposed environment. Air quality is considerably affected by agricultural burning due to the emission of aerosols and gaseous pollutants. PM (Particulate matter) 2.5 and PM 10 are reported to have the highest effect on the health of the exposed population. The air quality becomes austere mostly in November of each year across the north Indian states. The air quality of the urban areas is more affected by stubble burning emissions because of the presence of the accumulated pollutants from vehicular and industrial emissions leading to a severe air quality conditions. The air quality of a region can be categorized in terms of a parameter termed as the air quality index or AQI, which is a range of categorical measurements of the pollution level which helps in interpreting the quality of air in a region on a scale of 0-500 (Table 1). Most of the regions in North India have AQI beyond the safe limit, especially during the burning episodes.

Effect on soil fertility

Apart from the effects on air quality, stubble burning also affects soil productivity by burning the essential nutrients inside the soil (Table 2). It also raises the soil temperature to about 42°C, thus displacing or killing the important microorganisms in the soil at a depth of about 2.5 cm. This generates an additional expense of regaining back the soil fertility through the application of fertilizer or compost. Stubble burning strips the soil of the essential nutrients, i.e. Nitrogen, Phosphorus, and Potassium (NPK) as well as other micro-nutrients. For instance, the burning of rice stubble leads to a loss of about 0.445 Mt of NPK, 0.144 Mt in the case of wheat stubble burning.

Effects on agricultural productivity

The effects of burning crop stubble extend to the agricultural sector. The pollutants may affect agricultural productivity directly or indirectly. Direct effects entail injury to leaves, grains, or assimilation of heavy metals. For example, Nitrogen oxide can

damage the tissue of plants and cause discoloration. SO_2 may lead to the formation of acid rain which has severe effects on plants and soil, and may lead to plant mortality. Indirect effects include the provision of favorable conditions for the growth of pests or diseases. For example, the growth of aphid pests is favored by high concentrations of SO_2 and NO_2. Stubble burning releases VOCs and NOx which combine to form ground-level ozone. Ozone is formed in the immediate atmosphere by the reaction of nitrogen oxide and volatile organic compounds in the presence of solar radiation. Ground-level ozone affects plant's metabolism, penetrates, and destroys leaves causing serious effects on crops in the northern parts of India. Ozone was reported to greatly affect the performance of some crops such as wheat and soy, while crops like barley were known to possess some resistance to the same. Rice and maize were reported to be moderately affected. Hence, stubble burning negatively impacts agricultural productivity and needs to be dealt with appropriately to improve agricultural production to meet the increasing food demand.

Effects on human health and wellbeing

The harmful effects of exposure to air pollution range from skin and eyes irritation to severe neurological, cardiovascular, and respiratory diseases. In some cases, it may also lead to lethal effects especially when the exposed victim is having pre-existing respiratory problems. In chronic cases, exposure to a high level of air pollution may cause permanent health injuries such as the development of lung diseases like asthma, Chronic Obstructive Pulmonary Disease (COPD), bronchitis, lung capacity loss, emphysema, cancer, etc. Most of the farmers exposed to stubble smoke complain about eye and lung irritation and had spent a considerable amount of money on medical expenses.

Effects on climate

Emissions from stubble fires have a direct effect on weather and climate through the release of greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4) which may potentially lead to global warming. About 17% to 32% of the total annual greenhouse gas emissions in the world are contributed by the agricultural sector. India contributes about 12.2% to the global greenhouse gas emissions, which is about 658.823 Tg CO_2 equivalent. It was reported that India lost about 36% of its expected annual wheat yield in 2018, which was linked to the poor quality of air and change in the weather patterns.

CONCLUSION

The large-scale rice-wheat crop rotation system practiced in India has resulted in the generation of significant quantity of crop stubble of ten more than the quantity of grains harvested. A considerable portion of these stubbles is usually burnt on-field to clear the farm for the next planting, thus releasing toxic pollutants to the atmosphere which leads to the deterioration of air quality. It may be concluded (based on the

existing evidence) that the combined effects of stubble burning emissions and meteorological conditions are the cause of the severity of air quality especially during rice stubble burning episodes in north Indian cities. The pollutants from stubble burning pose a grave risk to the health of the exposed population as they are linked to several health issues and even death, in severe cases. In addition to atmospheric pollution, stubble burning may also lead to climate change, global warming, and the destruction of soil nutrients. It is, therefore, the need of the hour to implement exhaustive policies to curb this menace at its base.

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Table 1: Central pollution control board, India's AQI and particulate standards (Central Pollution Control Board, 2014)

AQI Ranges	**PM10 (24-hr)**	**PM2.5 (24-hr)**	**Category**
0-50	0-50	0-30	Good
51-100	51-100	31-60	Satisfactory
101-200	101-250	61-90	Moderate
201-300	251-350	91-120	Poor
301-400	351-430	121-250	Very Poor
401-500	430+	250+	Severe

Table 2: Loss of nutrients due to rice stubble burning in Punjab, India (Kumar *et al*., 2015).

Nutrient	**N**	**P**	**K**	**C**
Nutrient Content in Stubble (g/kg)	6.5	2.1	17.5	400
Percentage Lost due to burning (%)	90	25	20	100
Amount lost per hectare (kg/ha)	35	3.2	21	2400