INTRODUCTION

Rice (*Oryza sativa* L.) (2n = 24) is an Asian cultivated species. Rice is one of the most important cereal food crop of the world with occupying first place in world agriculture. Especially grown in tropics, it is the staple food for more than 60 per cent world population. In Asia, 90 per cent of world rice is produced and consumed, where it contributes 45 to 60 per cent of dietary energy.

In respect of area India ranks first followed by China. In annual production India ranks second after China. China contributed 185.6m. tones followed by India 136.8m. tones in 2006. In U.P. total area in lakh hectares was 62.35 and total production in lakh m. tones was 125.40 in 2005-2006 (Kushwah and Nagar, 2006).

By recognizing the potential of hybrid rice as a proven means to enhance production and productivity, Indian Council of Agriculture Research (I.C.A.R.), has initiated the national programme on hybrid rice breeding in 1989 in collaboration with IRRI, Philippines. G.B. Pant University of Agriculture and Technology has developed and released rice hybrid (Pant Shankar Dhan-I) in 1997. It was a first public sector hybrid of entire northern India.

The major goal of hybrid rice improvement in India is the development of widely adapted, high yielding, disease and insect resistant varieties responsive to improved cultural practices and
possessing tolerance to adverse climatic conditions. Improved nutritional and cooking characteristics are equally important. But limited research has been carried out on simultaneous improvement of grain yield in hybrid rice.

Air pollution is the most dangerous and common type of pollution of environment because we can not control the air we breathe. Most industrial towns and metropolitan cities are facing this ecological problem. According to a report of WHO (1970 & 1990) and National Environment Programme "In most of the cities of the world the air pollution created many crucial problems for the health. If it is to be said that air pollution is an identical part of city life, it would not be wrong".

Delhi, Faridabad, Ghaziabad, Modinagar, Meerut, Muzaffarnagar, Saharanpur and Hardwar, are the cities where a number of factories and industries have been established in the past 50 years. Sugar factories, Paper Mills, Rolling Mills, B.H.E.L. (Hardwar), Govt. Engineering Workshops, Rice Mills, Hosiery, Wood-carving, Plastic Industries and phosphate fertilizers are the major sources of air pollution.

Air pollution is a hazard to animal and plant life. To reduce the harmful effects of air pollution, efforts are being made at various levels such as (i) to eliminate or reduce the pollutants prior to their emission, (ii) to convert the toxic pollutants into non-toxic substances, (iii) to lessen the toxicity of pollutants by agronomic managements and (iv) to enhance the tolerance level of plants, and to eliminate or decrease the
overall phytotoxicity of pollutants. This may either increase the
tolerance of the plant to the pollutants or reduce the toxic effect of the
pollutants.

The response of a plant species to air pollutants, such as sodium
fluoride (NaF) is a function of the genetic constitution and
physiological status of the plant as well as of the external
environmental factors. Considerable differences in varietal sensitivity
to NaF and HF have been studied for wheat and other plant species
(Adedipe et al., 1972; Haggested et al., 1973).

Atmospheric fluoride reaches the plant in the form of a gas,
particulate matter, or gaseous fluoride absorbed to particles. The most
phytotoxic form of an atmospheric fluoride is gaseous hydrogen

In particular the yields of practically all crop plants and structure
of natural ecosystems are adversely affected by atmospheric pollutants.
Woodwell (1970) showed that accumulation of toxic substances in the
biosphere is causing serious changes in the structure and function of
natural ecosystem.

The chief fluoride containing minerals are fluorspar, cryolite and
fluorapatite. Soils contain fluoride in the form of several different
minerals, including biotite, muscovite, hornblende, apatite and fluoride
(fluorspar). The main sources of fluoride pollution are: manufacture of
brick and tile products, steel, combustion of coal, superphosphate
fertilizer plants, elements phosphorus, aluminium. non-ferrous metal
foundries, wet processes phosphoric acid, glass, welding operations,
diammonium phosphate fertilizer, phosphate animal feed, smelting industry, petroleum industry, fluorocarbons, aerosols, plastic, refrigerants, rock fuel and volcanoes (Leone, 1980 and NAS, 1971 a & b). The fluorine compounds released from these industries are HF, NaF, KF, CaF₂, sodium fluorosilicate, silicon fluorides and phosphatic slags.

Injury to plants apparently depends on absorption of fluoride into the tissue. Fluoride injury to plants can be divided into two types i.e. chronic and acute types. Chronic injury is produced by prolonged exposure to low concentration of fluoride. Acute injury develops under widely fluctuating fluoride concentrations or brief exposure to a high concentration, possible with a lower total fluoride exposure than required to cause chronic injury. Injurious effects by fluorides have been recognised in Alberta, where Cattle graze exposed forage crops, and in Southern Ontario, where soft suture in peaches result from continued accumulation of fluoride in leaves. The effects of fluoride was found by Weinstein (1961) on RNA-phosphorus and DNA-phosphorous levels in tomato and bean plants.

Fluoride inhibits the germination of seeds and causes necrotic lesions and chlorosis of germinating seedlings. The seeds showed threshold response of NaF upto 10 ppm concentration. Dwarfism, reduced growth, low biomass and productivity, low protein, phosphorus, chlorophyll and caloric values were recorded in higher concentrations of NaF (100-250 ppm) in pea, barley, wheat, corn, tomato, brinjal (Arya, 1971; Arya and Sunita Kumari, 1978; Arya et al., 1978, 1979; Agrawal, 1979 and Beniwal, 1979). Sunita Kumari
and Agrawal (1980) reported that toxic effect of NaF may be minimised by adding more NPK fertilizers than normal doses viz. \( \text{N}_2\text{P}_2\text{K}_2 \) and \( \text{N}_3\text{P}_3\text{K}_3 \) in onion (\textit{Allium cepa}) and broad bean (\textit{Vicia faba}).

Watson (1952) discussed the physiological basis of variation in yield. He determined the growth parameters such as NAR, RGR, and RLGR, in different crop plants. Toxic effects of fluoride on growth, NAR, RGR, RLGR, yield, productivity and biochemical characters such as chlorophyll content, nitrogen, protein and energy content were studied in various crop plants by Arya (1971), Singh (1992), Malik (1997), Arya (1997), Kumar (2000); Nimesh (2001), Chaudhary (2002), Saini (2003), Saini et al. (2004), Rawat (2005), Sharma (2005) and Singh (2006).

The relationship between biomass and productivity is a complex function of ecosystem maturity, food chain effects and environmental factors. The various transfers of energy in food chains are inefficient with the consequence that a large amount of photosynthetic production is required to support a comparatively small consumer biomass.

In the atmosphere, sulphurous acid is easily converted to sulphuric acid which is the major acidic component of "acid rain": \( \text{SO}_2 \) is acidic in nature and acts as an oxidizing agent, reducing agent and wet bleaching agent with temporary effect. Sulphur dioxide is emitted mainly from stationary sources that burn fossil fuels (coal, oil) such as power plants and refineries, or in the production of materials from sulphur bearing ores, such as copper smelting, sulphuric acid plants,
fertilizer and paper industries. Wood, natural gas, propane, and other common fuels used for home heating do not contain significant quantities of sulphur and, therefore, are not considered to be a major source of \( \text{SO}_2 \) where diesel fuel and to a lesser extent gasoline, contain sulphur and are considered a contributor to sulphur dioxide in the ambient air. This gas is highly corrosive and affects almost all materials such as metal, paper, clothing, paints and leather.

Among the various air pollutants, the oxides of Sulfur are probably the most widespread air pollutants. They include six different gaseous compound Sulfur Monoxide (SO), Sulfur dioxide (\( \text{SO}_2 \)), Sulfur trioxide (\( \text{SO}_3 \)), Sulfur tetraoxide (\( \text{SO}_4 \)), Sulfur sesquisoxide (\( \text{S}_2\text{O}_3 \)) and sulfur hepta oxide (\( \text{SO}_7 \)). which are produced mainly from burning of inorganic sulphides and sulphur bearing organic compounds in coal and oil. Of these, sulphur dioxide (\( \text{SO}_2 \)) is one of the principal contaminants of air. Sulfur dioxide is a colourless, inflammable and non explosive gas with a suffocating odour. It is highly soluble in water and acts either as reducing or as an oxidizing agent. \( \text{SO}_2 \) can produce \( \text{H}_2\text{SO}_4 \) droplets, \( \text{SO}_3 \) and salts of sulfuric acid. \( \text{SO}_2 \) is generally formed during the combustion of sulfur containing fuels or during smelting where sulfide ores are roasted. Plants are mute sufferers in a polluted atmosphere and they express their sufferings in the form of foliar injury and other symptoms of growth and yield reduction. Sulfur dioxide is absorbed into the mesophyll tissues of the leaves through the stomata. Toxicity is largely due to the reducing properties of the gas. Sulfur dioxide is a proper phytotoxicant and has been found to affect the vegetation adversely even at the concentration

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below 0.032 ppm (Heath, 1980). **High concentration of SO\textsubscript{2} over short period of time can produce injury.**

Different species of plants possess varied degrees of tolerance to SO\textsubscript{2} pollution. According to adedipe *et al.* (1972) differences in variety sensitivity to SO\textsubscript{2} for barely and other plant species were owing to morphological and physiological differences.

Mansfield and Majernick (1970) showed that stomata respond directly to SO\textsubscript{2} present in the atmosphere. In condition of low relative humidity, SO\textsubscript{2} suppressed stomata opening, but with higher water content in the atmosphere there is an appreciable stimulation of stomata opening. The latter effect is more likely to occur in natural condition and it will lead to increase the penetration of SO\textsubscript{2} into the leaves.

Photosynthesis is one of process to be affected first by SO\textsubscript{2} pollution. According to wellburn *et al.* (1972) photosynthetic pigments and many enzymes are associated with membrane of chloroplast. Higher concentration of concentration of SO\textsubscript{3}\textsuperscript{2-} resulted in non-competitive inhibition of enzyme.

Sulfur dioxide induced photosynthetic reduction is primarily due to from enhanced mesophyll resistance rather than photosynthesis suppression. Mesophyll resistance to CO\textsubscript{2} is increased by SO\textsubscript{2} when exposures are carried out at high humidity. Under SO\textsubscript{2} stress phloem loading system becomes a major limiting step in controlling translocation rate.
In Lolium perenne Bell et al (1979) advocated that SO$_2$ injury is more sincere on young plants. However, corresponding decline in shoot growth was observed. At higher concentration of SO$_2$ root as well as shoot growth reduced significantly.

Chlorophyll pigments are essential for photosynthesis. The reduction in chlorophyll a chlorophyll b and total chlorophyll contents due to SO$_2$ pollution have been noticed by a number of workers.

The kind of air pollution caused by explosives proves a serious threat to plant, animal and human lives. In this way, the problem of air pollution is not the problem of one country or nation alone, it is a global problem and has to be tackled on an international level. It is in recognition of this fact that the United Nations Organisation (U.N.O.) has already launched a world movement to combat the perils of pollution in a wide spread, co-operative and integrated manner. International. Conferences are being organised to bring together experts of different countries to hammer out ways and means of fighting the menace of environmental pollution.

In fact, air pollution is one of the most serious problems confronting mankind today. It is a matter of life and death. The nations and individuals must therefore, act together and make all possible efforts to solve this problem before it is too late. We who live and breathe, drink and eat and enjoy the gifts of nature today, owe a duty not to pollute the air, water and soil but see that this Earth is a clear, healthy and secure place for human dwelling. In our, own country attention has been paid to this problem. We have in our country the
Inventions Prevention Board and this Board is doing all that is possible to check the pollution of human environment caused by the discharge of petrol and diesel through automobiles and aeroplanes, smoky effusions from industrial units, city garbage and waste materials. The Board has been inviting suggestions for fighting pollution hazards and also issuing instructions to the people and owners of big mills and factories to make joint efforts for ending this evil to a great extent as possible. Government of India has converted the Central Public Health Department into National Environmental Engineering Research Institute (NEERI), Nagpur. It is hoped that with the efforts of this kind made not only in our country but in other countries also we shall be able to control atmospheric pollution, which has become today a great menace to our health. Let us hope that for coming generations this Earth will be a much cleaner and safer place to live and people will suffer less air pollution than what they suffer today.

The phytotoxic substances which are released from several industries, go to the soil through precipitation (rainfall, fog and dew) and are absorbed by the plants through their root system in the form of 'F' ions from sodium fluoride. Therefore, sodium fluoride which is readily soluble in water, was tried in various concentrations as a source of fluoride. Sodium fluoride contains 43% fluoride and 57% sodium. Control measures of air pollution have been adopted by EPA (Environmental Protection Agency) and AQCR (Air Quality Control Region) in U.S.A.

A few other U.N. Agencies like FAO, UNESCO, ILO, WHO and ESCAP are also actively involved in coordinating and supporting
some of the national or regional issues related to environment (Rasul, 1979). International Union of Air Pollution Prevention Associations (IUAPP A) was founded in 1964 with the union of six organisations. In India, we have the national committee on environmental planning and coordination (NCEPC), under the chairmanship of a distinguished Scientist, Dr. B.P. Pal. Indian Association for Air Pollution Control (IAAPC) was formed on 18th September 1976, at Department of Chemical Engineering, B.H.U. Varanasi (India).

Haryana Pollution Control Board announced various measures to simplify the procedure of consent management for the industry with a view to avoid unnecessary harassment and at the same time maintain a balance between development and protection of environment. The scheme would encourage pollution control facilities, including emission test plant (ETP), air pollution control management (APCM) and hazardous waste management unit.

Thus there is great problem of air pollution in Western Uttar Pradesh due to industrial cities like Ghaziabad, Noida, Modinagar, Meerut, Muzaffarnagar and Saharanpur. It is, therefore, very essential to work out the effect of these poisonous atmospheric gases, which are released from the factories on hybrid rice (*Oryza sativa* L.)

In view of the above problems, the present work of investigation entitled "Effect of fluoride and sulphur dioxide toxicity on the growth, yield and sterility behaviour of hybrid rice (*Oryza sativa* L.)" was conducted in the year 2008 at S.S.V. (P.G.) College, Hapur, (Ghaziabad), Uttar Pradesh with the following objectives.
1. To find out the tolerance and susceptibility of hybrid rice plants to fluoride and SO\textsubscript{2} pollutants and their relative toxicity.

2. To investigate the details of injury patterns on plant foliage and special sensitivity to sodium fluoride and SO\textsubscript{2}.

3. To study the growth biomass, productivity and biochemical effects e.g. chlorophyll, nitrogen, phosphorus, protein and energy content due to fluoride and SO\textsubscript{2} toxicity.

4. To investigate the sterility behaviour brought about in higher concentrations of fluoride and SO\textsubscript{2} pollutants.

5. To find out the suitability of Pragathi-1111 and Diamond-22 varieties of hybrid rice in Western U.P.