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IMPACT OF SIMULATED ACID RAIN ON THE GROWTH OF *SORGHUM VULGARE*

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The present research work aims to find the physiological alteration of *Sorghum vulgare* species affected with simulated acid rain. The 2pH, 3pH, 4pH, 5pH and 6pH acid rain grades are prepared by using sulphuric and nitric acids. The tap water is selected for control grade rain having 7pH. The *Sorghum vulgare* plots are prepared in respective grades of acids and sprayed it to the plants. Lose of leaf waxation, accumulation of phenolic compounds in leaf and steam and, necrosis are seen on the plants affected with acid rain. Acid rain also imparts changes in soil property. Accumulations of salts are the common problem of all simulated acid rain treated plots.

Keywords : Acid rain; Physiological alteration; *Sorghum vulgare.*

Introduction

Acid rain defined as precipitation with a pH less than 5.7 that results from reaction involving gases other than carbon dioxide. The sulphur dioxide (SO_2) and oxides of nitrogen (NOx) are involved in formation of acid rain. The principle countributory sources of these gases are human activities like emissions from automobiles, industries, and smelting industries. The first incidence of acid rain seems to have with the on-set of industrial revolution in mid 19th century. British chemist Robert Angus Sumita first introduced the term acid rain in 1872. Acidic precipitation creates serious environmental problems in many parts of North America, Europe and Asia. In 1981, Norwegian scientist observed polluted snowfall and attributed it to large towns of industrial districts in England. In Australia and England from year 1911 to 1919 it was observed that rain with diluted Sulphuric acid inhibited the plant growth. In 1982 the 18,000 lakes in Sweden were acidified because of acid rain. Acid sensitive species disappeared from roughly 1,20,000 Sq. km of this area.

Global industrial out-put of Sulphur in 1978 was about 65,000,000 metric tones, which may be compared with estimated 64,000,000 metric tones per year. Industrial sources of oxidized nitrogen are similarly dominant. The global industrial out-put of NOx is about 20,000,000 metric tones per year. Combination of fossil fuels accounts for about 40% of the NOx, whereas bio-mass burning accounts for another 25%. These gases when liberated in atmosphere are converted in to Sulphuric acid (H_2SO_4) and Nitric acid (HNO_3), respectively.

In India the Sulphur emission are expected to rise from 4,400 Kilotons (Kt) in 1990 to 6,500 Kt in 2010 and 18,500 Kt in 2020. It is, therefore, not surprising that low pH levels have been reported from Delhi, Utter Pradesh, Maharashtra, Madhya Pradesh, Tamil Nadu and even the Andaman Islands. While this will not result in acid rain, the stage has been set for it and if conditions worsen the area may receives acid rain. Scientists predicted that many cities of India will leads to increase acids in near future. During last two decades contents of acids in rain water samples, collected from Delhi, have been increased, this clearly indicate from the level of pH 7.0 in 1955 to 6.1 in 1984, while in Agra city acidity of rain water is recorded pH9.1 in 1963 and 6.3 in 1984. The pH level of the Andaman Island fluctuated between 5.6 and 8.9. Acid rain may cause irreparable damage to the India's biodiversity and even damage the food chain[1].

Adverse effectes of acid rain are most servere when pH is below 3. The effect of acid rain on the terrestrial biosphere is more ambiguous. The acidic precipitation has been found to damage various kinds of vegetation including agricultural crops and trees, chiefly by inhibiting nitrogen fixation and plant's roots being damaged in acidic soil. Soil micro-organisms are lost by heavy acid depositions. The acid rain damages waxy layer of the leaf and plants can not survive under adverse conditions. Wood Tim and Bormann[2], analyzed that acidified precipitation affected the forests and alters plants nutrients. Anna-Santos *et al.*[3] observed that, occurrence of necrotic intervenial spots, collapsing of epidermis and

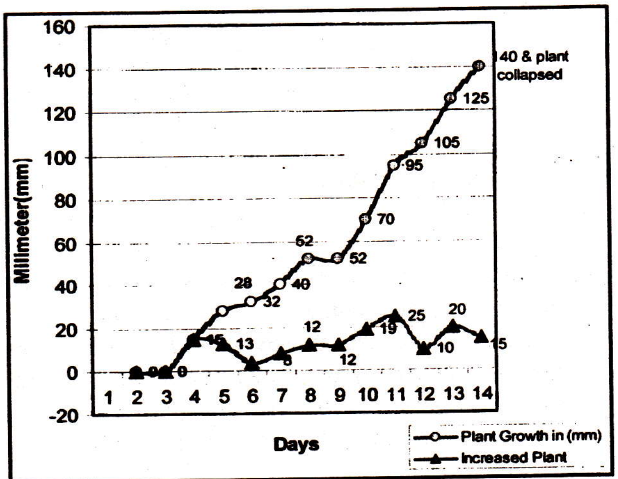

Fig.1. Growth of *Sorghum vulgare* at 2 pH simulated acid rain.

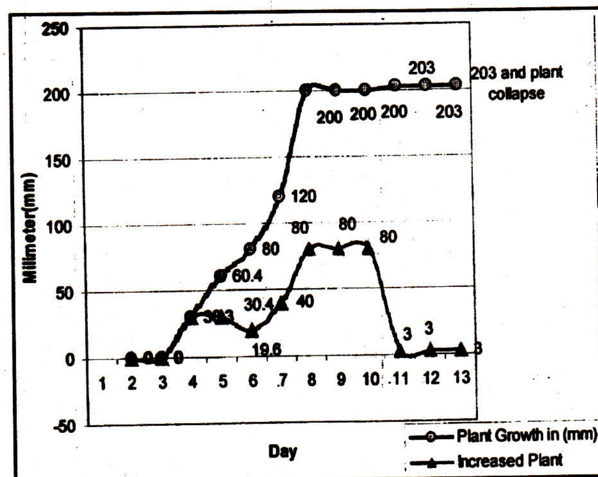

Fig.2. Growth of *Sorghum vulgare* at 3 pH simulated acid rain.

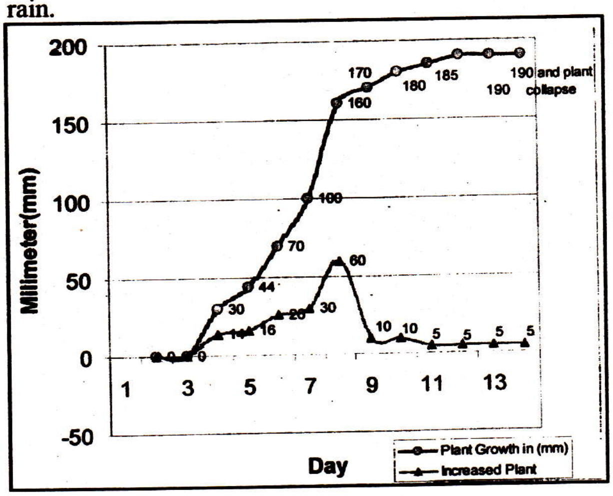

Fig.3. Growth of *Sorghum vulgare* at 4 pH simulated acid rain.

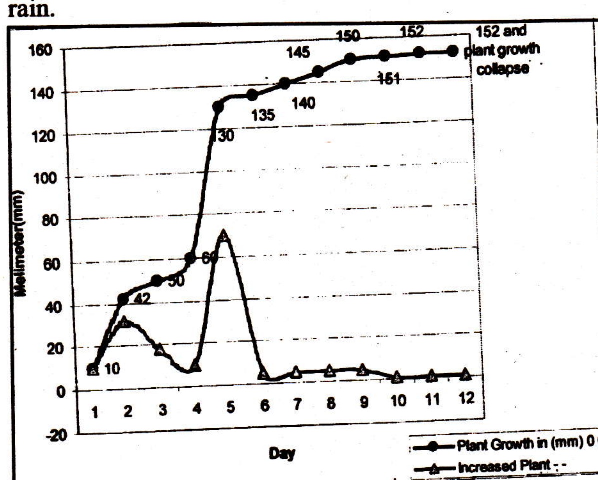

Fig.4. Growth of *Sorghum vulgare* at 5 pH simulated acid rain.

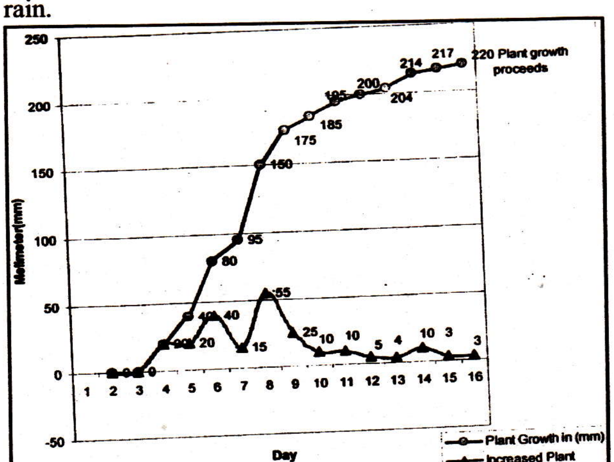

Fig.5. Growth of *Sorghum vulgare* at 6 pH simulated acid rain.

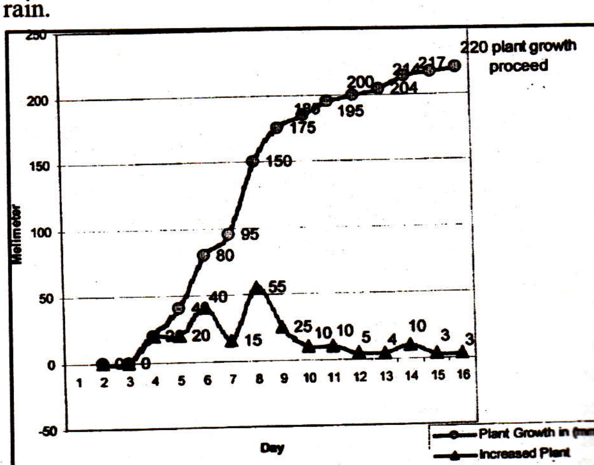

Fig.6. Growth of *Sorghum vulgare* at 7 pH simulated acid rain.

Fig.7. Growth of *Sorghum vulgare* (on 8th day) affected by various grade acid rains.

mesophyll cells, hypertrophy of spongy parenchyma cells, accumulation of phenolic compounds and starch granules in acid rain exposed leaves. Wellburn[4] observed that cellular part of the leaf is affected due to acid rain phenomena. Dursun *et al.*[5] found that effects of acid rain of low pH have negative effect on plant development and yield.

The acid rain problems may be very grim in future if pollution emission trends are continues, in this context the present research work have demarcate the physiological changes occur in plant affected by acid rain. The *Sorghum vulgare* species selected for analyzing growth and growth curve. The *S. vulgare* popularly known as Jowar. Due to limitation of the study plant growth were measured only for 15 days in laboratory condition with the use of various grades of these acids (2pH-6pH).

Material and Methods

The simulated acid rain solutions were prepared by mixture of dilute Sulphuric acid and Nitric acid (60 : 40) with different grades like 2pH, 3pH, 4pH, 5pH and 6pH, and 7pH grade used as a control. The seeds of *S. vulgare* were germinated in different plots. The black cotton soil beds were prepared for sowing of *S. vulgare*. The acid rain grades were filled in mechanical hand sprayer and acted like rain shower.

For initial germination of plant it was necessary to use the neutral condition water. Therefore, for initial two days all seedling plots were sprayed by control grade formulation. From 3rd day to 15th day all plots were daily sprayed with respective pH grades of acids. Growth (cm) of *S. vulgare* every day. These experiments were stopped at 15th day because of collapse of plants after 13 days.

Results and Discussion

The 2pH, 3pH, 4pH, 5pH, 6pH and control grades simulated acid rain showed impact were on *S. vulgare* (Fig. 1-7). Acid rain exposed plants change its morphology, anatomy, physiology and biochemistry[6-8]. The growth of 2pH, 3pH, 4pH acid rain treated plant was stunted after 13th day; because of loss in turgidity. The turgidity reduction in the subsidiary cells induced the alterations in the guard cells permeability[9]. The problem of necrosis was seen on leaf blade after 8th day. The necrosis occured because of adaxial leaf surfaces were directly exposed to pollutants[10]. Growth of *S. vulgare* was stunted after 13th days of seed sowing. Damage caused to the stomata impaired the growth of plant and reduced photosynthesis process.

The chlorosis problem was observed in 3pH, 4pH and 5pH grades acid rain affected plants. Chlorosis inhibited the activity of chlorophyll pigment and reduced the biomass of infected plant and reduced the photosynthetic activity[6]. The problem of epinasty was seen in 2 pH and 3 pH simulated acid rain affected *S. vulgare*. These plants initially grow faster by mobilizing enzymes activity which resulted in downward curvature of leaf blade because of increase in phenolic compounds in plants[11]. The accumulation of phenolic compound was generally followed by cytoplasm degradation and vacuolar contents were released and it lead to cell death[3]. Leaves exposed to low pH has hypertrophy and hyperplasia of mesophyll cells[8,12]. In *S. vulgare* the hypertrophy problem occurred in 2pH, 3pH grade affected plants. Leaf wrinkling and curling were also registered because of hypertrophy and hyperplasia[13].

Drop of leaf waxation occured in 2pH, 3pH, and 4pH grade treated plots. In 2pH grade affected plant leaf waxation was lost in 4days. Leaf waxation was lost because of cells near necrotic areas showed alterations in the differentition pattern without a typical palisade and spongy mesophyll[3]. The acid deposition on soils caused leaching of free calcium carbonate and therefore, this has not strongly buffered, such addition of acid can be harmful to plants. The salts were accumulated in 2pH, 3pH, 4pH and 5pH grade plots. The leaching of minerals by simulated acid rain impart the salinity which has negatively impact on growth of plant and root[2] of *Sorghum vulgare.*

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