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Ecophysiological aspects of environmental pollutions on plants growth

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ABSTRACT: By definition, pollution is the undesirable state of the natural environment being contaminated with harmful substances as a consequence of human activities. It has been mentioned that, Air, water and soil, the three major natural resources, have been found to be heavily contaminated with harmful substances throughout the world. For example, Air pollution comes from natural sources and human activities; these sources generate pollutants with different effects at global level or on individuals of plants and animals. It has been reported that the projected levels of air pollutants are critically alarming, and have become a major issue of concern for food security worldwide. So under such conditions, future work around the world will help provide new and much needed insight into the nature of the plant response to air pollutants and ways and means to help circumvent their deleterious effects. In general, it has been conclude that, it is quite clear that we will need proper engineering of crops to combat the emerging problem, and researches, analysis, and reviews on initial crop-pollutants interaction have pointed toward some important functional traits required while considering the next-generation crops.

***Keywords*:** engineering of crops; food security; growth; pollution; production.

INTRODUCTION

By definition, pollution is the "undesirable state of the natural environment being contaminated with harmful substances as a consequence of human activities" (source- http://wordnet.princeton.edu). But, at present, this 'undesirable state of natural environment' has turned into a major concern for the survival of life on Earth. Air, water, and soil – the three major natural resources, and fundamental backbone of Earth's environment, have been found to be heavily 'contaminated with harmful substances' throughout the world (Sarkar, 2012). The effects of pollution on plants include mottled foliage, "burning" at leaf tips or margins, twig dieback, stunted growth, premature leaf drop, delayed maturity, abortion or early drop of blossoms, and reduced yield or quality. In general, the visible injury to plants is of three types: (1) collapse of leaf tissue with the development of necrotic patterns, (2) yellowing or other color changes, and (3) alterations in growth or premature loss of foliage. Injury from air pollution can be confused with the symptoms caused by fungi, bacteria, viruses, nematodes, insects, nutritional deficiencies and toxicities, and the adverse effects of temperature, wind, and water (Sikora and Chappelka, 2004). Plant injury caused by air pollution is most common near large cities, smelters, refineries, electric power plants, airports, highways, incinerators, refuse dumps, pulp and paper mills, and coal-, gas-, or petroleum-burning furnaces (Sikora and Chappelka, 2004). Plant injury also occurs near industries that produce brick, pottery, cement, aluminum, copper, nickel, iron or steel, zinc, acids, ceramics, glass, phosphate fertilizers, paints and stains, rubbers, soaps and detergents, and other chemicals (Sikora and Chappelka, 2004). Damage in isolated areas occurs when pollutants are spread long distances by wind currents (Sikora and Chappelka, 2004). The sensitivity of plants to pollution depends largely on their general condition. Identification of factors limiting the growth and development of plants in polluted areas may contribute to a better understanding of the mechanisms of plant sensitivity to toxic compounds and may help to formulate guidelines for reforestation of degraded areas (Bojarczuk, 2002). The aim of this review was to analysis the influence of pollutants on the physiology and growth of plants.

1-Sources of pollutants

Air pollution comes from natural and anthropic sources; these sources generate pollutants with different effects at global level or on individuals of plants and animals. Natural processes that affect air quality include volcanoes, which produce sulfur, chlorine, and ash particulates. Wildfires produce smoke and carbon monoxide. Cattle and other animals emit methane as part of their digestive process. Even pine trees emit volatile organic compounds (VOCs) (Gheorghe and Ion, 2011). Many forms of air pollution are human-made. Industrial plants, power plants and vehicles with internal combustion engines produce nitrogen oxides, VOCs, carbon monoxide, carbon dioxide, sulfur dioxide and particulates (Gheorghe and Ion, 2011). In most mega-cities, cars are the main source of these pollutants. Stoves, incinerators, and farmers burning their crop waste produce carbon monoxide, carbon dioxide, as well as particulates. Other human-made sources include aerosol sprays and leaky refrigerators, as well as fumes from paint, varnish, and other solvents (Gheorghe and Ion, 2011). One important thing to remember about air pollution is that it does not stay in one place (Gheorghe and Ion, 2011).

2- Evaluation of air pollutants effects on plants

2-1- Sulfur Dioxide (SO2)

The exposure of succulent, broad-leaved plants to sulfur dioxide (SO2) and its by-product sulfuric acid usually results in dry, papery blotches that are generally white, tan, or straw-colored and marginal or interveinal. Injured grass blades develop light tan to white streaks on either side of the midvein. Growth suppression, reduction in yield, and heavy defoliation may also occur. Middle-aged leaves and young plants are most susceptible to sulfur dioxide (Sikora and Chappelka, 2004). Sulfur dioxide injury can be severe 30 miles or more from its source. Injury, however, is usually greatest in the vicinity of the source (less than 1 to 5 miles away). Sources of sulfur dioxide include electric power plants, copper and iron smelters, oil refineries, chemical factories, and other industries that burn soft coal, coke, or high-sulfur oil as fuel (Sikora and Chappelka, 2004). The degree of injury increases as both the concentration of sulfur dioxide and the length of exposure increase. Plants are most sensitive to sulfur dioxide during periods of bright sun, high relative humidity. Some of very sensitive crops are included alfalfa, barley, bean (broad and garden), beet (table and sugar), clovers, cotton, rye, ryegrass, safflower, soybean, spinach, squash, sunflower, sweet potato, tomato and wheat (Sikora and Chappelka, 2004). Among crops, corn and sorghum are somewhat resistant (Sikora and Chappelka, 2004).

2-2-Fluorides

Fluorides are compounds containing the element fluorine (F). The typical injury by gaseous or particulate fluorides is either a yellowish mottle to a wavy, reddish brown or tan “scorching” at the margin and tips of broad-leaved plants or a “tipburn”. Fluorides are produced by glass, aluminum, pottery, brick, and ceramic industries and by refineries, metal ore smelters, and phosphate fertilizer factories (Sikora and Chappelka, 2004). Accumulated leaf-fluoride concentrations of 20 to 150 ppm often injure sensitive plants, although resistant varieties and species of plants will tolerate leaf concentrations of 500 to 4,000 ppm or more without visible injury (Sikora and Chappelka, 2004). Susceptibility to fluorides varies tremendously among varieties or clones of the same plant, such as corn and sweet potato. The extent of tissue damage is related to the dosage and the quantity of fluoride accumulated (Sikora and Chappelka, 2004). Among crops, bean, cotton, cucumber, eggplant, soybean, spinach, squash, tobacco and tomato are somewhat resistant (Sikora and Chappelka, 2004).

2-3- Chlorine

Injury caused by chlorine (Cl2) is somewhat similar to that caused by sulfur dioxide and fluorides, in that it is marginal and interveinal. On broad-leaved plants, necrotic, bleached, or tan to brown areas tend to be near the leaf margins, tips, and between the principal veins (Sikora and Chappelka, 2004). Hydrogen chloride and chlorine are emitted from the stacks of glassmaking factories and refineries. These gases are also produced by incineration, scrap burning, and spillage, such as from chlorine storage tanks. Chlorine-injured vegetation is often observed near swimming pools, water-purification plants, and sewage-disposal facilities (Sikora and Chappelka, 2004). Very susceptible plants show symptoms when exposed for 2 hours or more at concentrations of chlorine ranging from 0.1 to 4.67 ppm. Chlorides do not accumulate in plant tissues after exposure to chlorine (Sikora and Chappelka, 2004). Among crops, eggplant and soybean are somewhat resistant to chlorine (Sikora and Chappelka, 2004).

2-4- Ozone (O3)

Ozone (O3) is a very active form of oxygen that causes a variety of symptoms on broad-leaved plants: tissue collapse, interveinal necrosis, and markings on the upper surface of leaves known as stipple (pigmented yellow, light tan, red brown, dark brown, red, black, or purple), flecking (silver or bleached straw white), mottling, chlorosis or bronzing, and bleaching. Ozone stunts plant growth and depresses flowering and bud formation. Affected leaves of certain plants, such as citrus, grape, and tobacco, commonly wither and drop early (Sikora and Chappelka, 2004). The injury pattern in small grains and forage grasses generally occurs as a scattering of small, yellowish or white to tan flecks on one or both leaf surfaces. The flecks may later merge to form larger, bleached white to yellowish dead areas. Ozone usually attacks nearly mature leaves first, progressing to younger and older leaves. Young plants are generally the most sensitive to ozone; mature plants, relatively resistant. Ozone-killed tissues are readily infected by certain fungi, such as Botrytis (Sikora and Chappelka, 2004). Plant resistance to O3 involves a wide array of response ranging from the molecular and cellular level to the whole plant level. Significant effects of O3 are early leaf senescence, decreased photosynthetic assimilation, altered stomatal behavior, decreased growth and productivity, and reduced carbon allocation to roots and changes in metabolic pathways. Genotype differences in response to O3 are related to stomatal behavior, anti-oxidative potential hormonal regulation, and carbon allocation during reproduction affecting the yield responses (Sarkar et al., 2012). Detailed understanding of genotypic response is crucial in predicting the long-term impacts of O3 on agriculture in global context, including the breeding of resistant cultivars. Several potential O3 biomarkers have been identified, which could be exploited to screen and develop O3-tolerant varieties in future (Sarkar, 2012).

2-5- Carbon dioxide (CO2)

CO2, it is an integrated compound for plant's survival. So, at the initial stages, any increment in the ambient CO2 levels showed a positive response towards plants yield, but also raised many questions (Sarkar, 2012). The prevailing view among scientists is that global climate change may prove beneficial to many farmers and foresters, at least in the short term. The logic is straightforward: Plants need atmospheric carbon dioxide to produce food, and by emitting more carbon dioxide into the air, our cars and factories create new sources of plant nutrition that will cause some crops and trees to grow bigger and faster. But an unprecedented three-year experiment conducted at Stanford University is raising questions about that long-held assumption. Writing in the journal *Science*, researchers concluded that elevated atmospheric carbon dioxide actually reduces plant growth when combined with other likely consequences of climate change namely, higher temperatures, increased precipitation or increased nitrogen deposits in the soil. The results of the study may prompt researchers and policymakers to rethink one of the standard arguments against taking action to prevent global warming: that natural ecosystems will minimize the problem of fossil fuel emissions by transferring large amounts of carbon in the atmosphere to plants and soils (Shwartz, 2002).

3- Soil pollution

The toxic levels of heavy metals appear as a result of environmental pollution due to the removal technology of mining, heavy traffic, smelting, manufacturing, and agricultural wastes in natural and agricultural areas (Oncel, 2000). These metals are not readily removed or degraded by chemical or microbial processes and tend to accumulate in soils and aquatic sediments (Odjegba, and Fasidi, 2007). The toxicity of these heavy metals to plants varies with individual metal and concentrations. Induction of leaf chlorosis, reduction of biomass production and nutritional quality has been observed on crops grown in soils contaminated with moderate levels of heavy metals (Clijsters, 1999). The increasing levels of these metals in the environment, their entry into food chain and the overall health effects are of major concern to researchers in the field of environmental biology (Odjegba, and Fasidi, 2007). Toxic ions inhibit root development and at higher concentrations lead to root necrosis or death (Bojarczuk, 2000; Mohr, 1985; Silva, 2001). The toxic influence of metal ions on plants can be most effectively limited by reducing industrial air pollution. However, even if emissions are greatly reduced, the toxic compounds accumulated in the soil may exert a negative impact on root system development for many years (Komisarek, 1990).

4- Water pollution

Industrial agriculture is among the leading causes of water pollution in the United States today. In the 2000 National Water Quality Inventory conducted by the Environmental Protection Agency (EPA), agricultural activity was identified as a source of pollution for 48% of stream and river water, and for 41% of lake water (Anonymous, 2014). Most water pollution from industrial farms results from the storage and disposal of animal waste. Industrial livestock farms store manure and other farm wastes in gigantic tanks known as “lagoons” which can hold millions of gallons of manure and urine. Unfortunately, these lagoons often leak and—during large storms—they may rupture or simply overflow. When this happens, the environmental damage can be devastating, as raw manure is up to 160 times more toxic than raw municipal sewage. Leaking lagoons also release antibiotic residues and harmful bacteria that can leach into water supplies (Anonymous, 2014). In order to dispose of manure after it's been stored in lagoons; industrial farms spray the waste onto farm fields as fertilizer. Unfortunately, these farms produce far more waste than can be applied to fields, and once the saturation point has been reached, the waste runs off into nearby water systems. The most common form of water pollution in the United States is excess levels of nitrogen or phosphorous, both of which are largely caused by fertilizer runoff. When manure is spread on fields as a fertilizer, it can also introduce some of the more toxic substances present in livestock excretions, such as pharmaceuticals or bacteria. Water pollution from manure as well as synthetic fertilizers can lead to serious environmental damage and harm human health (Anonymous, 2014). For example many ponds have experienced accelerated eutrophication, a process where water bodies receive excess nutrients through runoff. The nutrients stimulate excessive plant growth, and the aquatic ecosystem becomes unbalanced. Decaying vegetation negatively impacts water quality by reducing dissolved oxygen levels and releasing nutrients which fuel more vegetative growth. Organic matter that is not decomposed adds to the bottom sediments which accumulate until the pond no longer effectively manages runoff volume.

The resultant flooding leads to issues of public health, liability, economic loss, and environmental problems. Pond renovation adversely impacts the surrounding environment and is very expensive (Fox et al., 2008).

CONCULSION

The projected levels of air pollutants are critically alarming, and have become a major issue of concern for food security worldwide. Scientific evidences indicate that crop plants are in general sensitive to air pollutants, but in different ways. Future work around the world will help provide new and much needed insight into the nature of the plant response to air pollutants and ways and means to help circumvent their deleterious effects. It is quite clear that we will need proper engineering of crops to combat the emerging problem, and researches, analysis, and reviews on initial crop-pollutants interaction have pointed toward some important functional traits required while considering the next-generation crops (Sarkar et al., 2012).

REFERENCES

Anonymous. 2014. Water quality. GRACE Communications Foundation. Available at: http://www.sustainabletable.org/267/water-quality

Bojarczuk K. 2000. Effect of aluminium on in vitro rooting of berch (Betula pendula Roth.) and poplar (Populus tremula L. P.alba L.) microcuttings. Acta Societatis Botanicorum Poloniae 69(4): 251.

Bojarczuk K, Karolewski P, Oleksyn J, Kieliszewska-Rokicka B, Żytkowiak R, Tjoelker MG. 2002. Effect of Polluted Soil and Fertilisation on Growth and Physiology of Silver Birch (Betula pendula Roth.) Seedlings. Polish Journal of Environmental Studies 11(5): 483-492.

Clijsters H, Cuypers A, Vangronsveld J. 1999. Physiological response to heavy metals in higher plants; Defence against oxidative stress. Zeitschrift fu¨r Naturforschung 54c: 730–734.

Fox LJ, Struik PC, Appleton BL, Rule JH. 2008. Nitrogen Phytoremediation by Water Hyacinth (Eichhornia crassipes (Mart.) Solms). Water Air Soil Pollut 194:199–207.

Gheorghe IF, Ion B. 2011. The Effects of Air Pollutants on Vegetation and the Role of Vegetation in Reducing Atmospheric Pollution. In: Khallaf, M (eds). The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources. InTech, Available from: http://www.intechopen.com

Komisarek J, Kocialkowski WZ, Rachwal L, Sienkiewicz A. 1990. Wptyw CaCO3 na zawartosc roznych form Cu, Zn i Pb w glebach skazonych. PTPN Prace Komitetu Nauk Rolniczych i Nauk Lesnych 59, 53.

Mohr HD. 1985. Extraction of easy soluble of Fe and other heavy metals from various substances by electro-ultrafiltration (EUF) and their relation to the heavy-metal contents of plants. Plant and Soil 83, 65.

Odjegba VJ, Fasidi IO. 2007. Phytoremediation of heavy metals by Eichhornia crassipes. Environmentalist 27:349–355.

Oncel I, Kele Y, Ustun AS. 2000. Interactive effects of temperature and heavy metal stress on the growth and some biochemical compounds in wheat seedlings. Environmental Pollution 107(3): 315–320.

Sarkar A, Agrawal GK, Cho K, Shibato J, Rakwal R. 2012. Impacts of Ozone (O3) and Carbon Dioxide (CO2) Environmental Pollutants on Crops: A Transcriptomics Update. In: Crop Plant, Goyal A (Ed.), InTech, Available from: http://www.intechopen.com/books/crop-plant/impacts-of-rising-co2-and-o3-environmental-pollutants-on-cropsa-transcriptomics-update

Shwartz M. 2002. High carbon dioxide levels can retard plant growth, study reveals. Stanford University. Available at: http://news.stanford.edu/news/2002/december11/jasperplots-124.html

Sikora EJ, Chappelka AH. 2004. Air Pollution Damage to Plants. Alabama Cooperative Extension System. www.aces.edu

Silva IR, Smyth TJ, Raper DC, Carter TE, Rufty TW. 2001. Different aluminium tolerance in soybean. An evaluation of the role of organic acids. Physiologia Plantarum 112, 200.