Physico-chemical properties and Manganese concentration effects on biochemical activities in cereals crops grown in degraded soil

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Abstract

Degraded soil has now become an important factor in agricultural economy. Human activities are responsible for land degradation, as construction of large-scale canals for irrigation purposes, deforestation and faulty land use, salinization, drought and water-logging. These processes also reduce the availability of essential minerals. Manganese is an essential micronutrient for plant growth, development and intervening in several type of metabolic activity, mainly in photosynthesis and chlorophyll concentration in different types of plants. Manganese is also essential co-factor for the oxygen-evolving complex of the photosynthetic machinery of plants life cycle and catalyzing the water-splitting reaction in photosynthetic- II process.

Nevertheless, excess amount of Manganese is available in soil for plant affecting the plant's growth and become toxic for them. Manganese phytotoxicity is manifested in the reduction of plant biomass, photosynthetic rate and different type of bio-chemical disorders like; oxidative stress, chlorosis on young leaves, necrotic dark spot on mature leaves and crinkled leaves. An important role of antioxidative system in plant in high amount of Manganese has been also reported as a defense mechanism for plants. In the collected sample of degraded soil, the availability of different types of elements is very poor in concentration and other physico-chemical properties are also reduced in degraded soil.

Keywords: Plant growth, Phytotoxicity, Photosynthesis, Defense mechanism, Antioxidative enzyme.

Introduction

Degradation of top most layer of soil has become a serious environmental problem in both rain-fed and irrigated areas of India. Land degradation cost in India is very high in comparison with other countries because the rate of land degradation in India is more severe. The documented cost of land degradation is declining crop productivity, land use intensity, change in the crop use pattern, using the high amount of input cost and it also affects the profit and loss of production. Some other types of additional losses are estimated, resulting in salinization, alkalinization and water logging. A comprehensive study made on the impact of water erosion on crop production revealed that soil erosion due to water flow resulted in significant annual loss in crop yield.

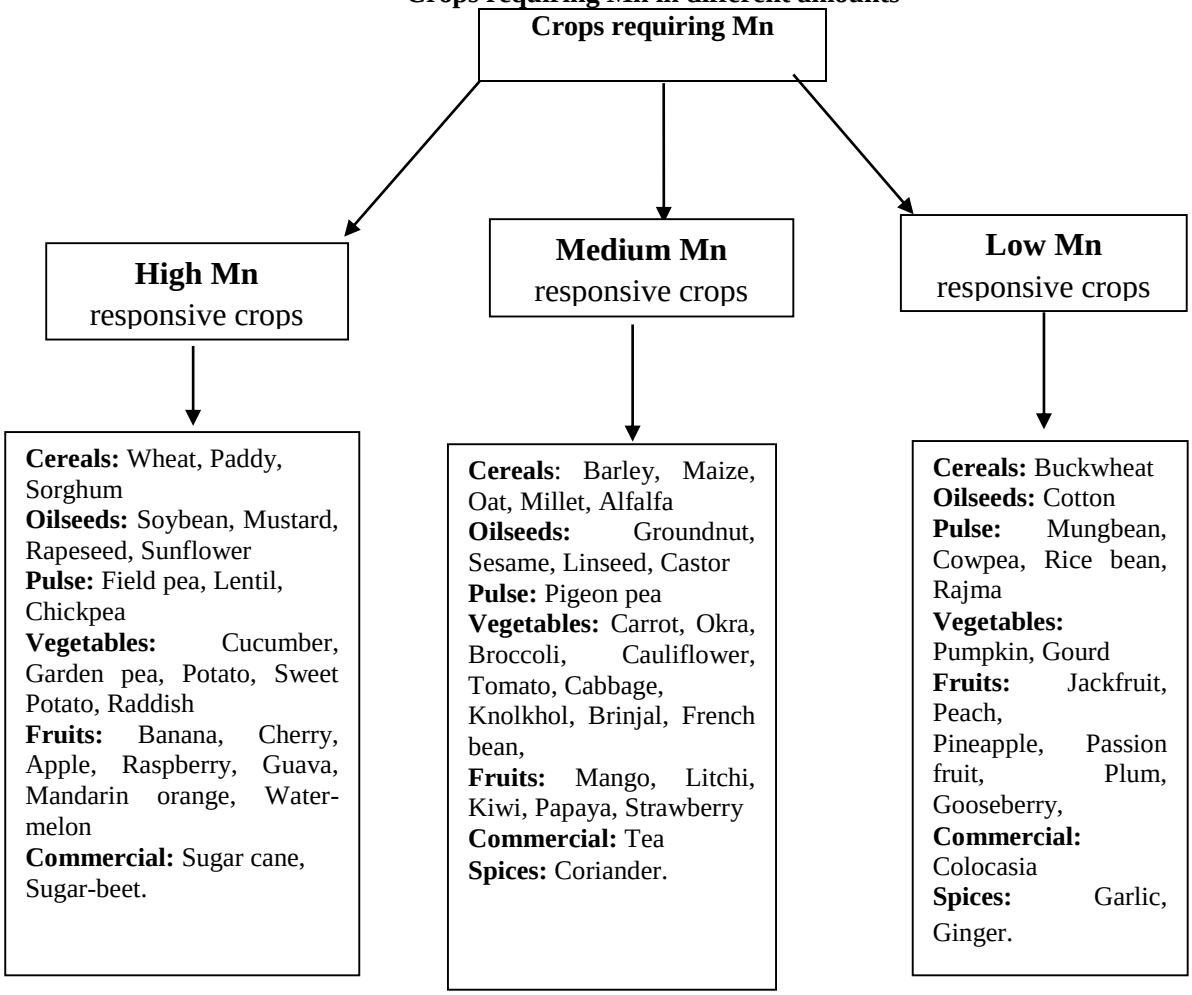
Apart from the above defective and damaged agricultural activities that lead to land degradation, some other human-induced activities that lead to land degradation include: cleaning of land, careless management of forests, deforestation and inappropriate management of industrial effluent, surface mining and industrial developmental activities that also play a leading role in land degradation. Excessive pressure to meet the competing demands of the rising population for food, fodder and fiberent is one of the main causes of land degradation.

Different types of human activities are responsible for land degradation like the construction of extensive canals for irrigation purposes, incorrect land usage and deforestation leading to the acceleration of soil degradation brought on by water logging, drought, flooding and salinization. The output of agriculture is decreased by these activities, which leads to agricultural insecurity. Emission of greenhouse gases into the atmosphere from various sources resulting in the global warming is the major reason for soil degradation. Other factors contributing to land degradation as a result of both direct and indirect human intervention include overgrazing, deforestation, removal of native vegetation, agriculture-related activities and excessive use of the vegetation for domestic use.

Manganese is the most important element for plant growth and their antioxidative properties. Manganese content in degraded soil is very important for the growth of cereal plants and their reproductive yield. In different types of cereal plants, manganese participates in structural role of photosynthetic proteins and enzymes. Deficiency of manganese in plants is dangerous for chloroplasts formations affecting the water-splitting system of photosystem II (PS II), which provides the necessary electrons for photosynthetic process[3].

Excess of Manganese seems also to participate in particularly damaging the photosynthetic apparatus[12]. Consequently, Manganese plays a double role in the plants metabolic processes: as essential micronutrients and as a toxic element or its excess concentration[4,8].

Table 1
Crops requiring Mn in different amounts



Excessive concentration of manganese in plants tissues can make differences in various processes such as enzymes activity, absorption, translocations and utilization of other mineral elements (Ca, Mg, Fe and P), causing the oxidative damage[4,9]. Threshold level of Manganese injury as well as the tolerance to the excess of this metal highly depends on the plant to plants species and cultivars or genotypes within a species[5,7].

Material and Methods

Soil sample collection: The soil sample of degraded soil was collected from the rural non-agricultural site in Arjunganj near the Lucknow district head quarter for the assessment of physico-chemical properties and Manganese concentration. In collected soil samples, there was no previous use of fertilization (control soil sample). The soil samples were collected in polyethylene bags, with proper label and stored in laboratory at 4°C prior to further analysis. To obtain the reference data, soil sample was collected from the agricultural lands.

Physico-chemical properties of soil: Physico-chemical properties of collected soil samples were determined by the standard procedures. Soil textures were analyzed with the use of different sieves by the methods prescribed by Alexander[1] whereas water organic carbon, total nitrogen and soluble phosphorous of soil samples were determined by prescribed methods. Exchangeable bases of Ca, K and Na, soil pH and electric conductivity were determined by conductivity meter and pH meters respectively. Trace metal concentration of Manganese in soil samples was estimated by the method prescribed by Lindsay and Norvel[10].

Results and Discussion

Collected degraded soil samples from sampling site were analysed for their physico-chemical characteristics and their results are represented in table 2. The soil texture of the collected sample was sandy loam in nature due to the high sand percentage. Water holding capacity of the collected soil sample was low due more content of sand, which decreased the water holding capacity of soil collected as test sample.

Electrical conductivity (EC) of the collected soil sample was 0.29. EC is an essential indicator of soil health; it affects crop yield, crop suitability, nutrients availability and activity of soil micro-organism. Similar types of studies were done in past[14]. Increase in EC in soil may be due to the industrial effluent. Organic matter of the collected degraded soil samples was 9.16 %. Higher concentration of organic matter in the collected soil samples may be due to the discharge of

waste water from different sources, this increased the organic matter enhancing the soil enzyme activity.

Table 2
Physico-chemical characteristics of soil and Manganese content in collected soil samples near Lucknow (Arjunganj).

Soil properties	Results
Manganese (mg $kg^{-1)}$	0.336±0.044
pH	7.26
Soil texture	Sandy loam
Electrical conductivity (µS/cm)	0.29
Organic matter (%)	9.16
Sodium (Na)	7.40
Calcium (Ca)	3.5
Sulphur (S)	57.69
Phosphorous (P)	20.00
Nitrogen (N)	50.4
Potassium (K)	35.5

The pH value of the collected soil sample was alkaline in nature and it was 7.26. Soil sample pH value is basic in nature, because deposition of different minerals affects the pH value of the uncultivated soil. The concentration of different types of nutrient in collected soil samples were decreased because soil is uncultivated and degraded in nature. Deposition of different types of nutrients such as calcium, sulphur, phosphorous, nitrogen, potassium in the collected soil sample was lower in concentration. Availability of different nutrients in soil mainly depends on the physical, chemical and biological changes which occur during soil transformation process.

The Manganese concentration in the soil mainly depends on the soil pH and the value of Mn is 0.336 mg kg^{-1}. Thus, the concentration of manganese in the soil sample increased when the soil pH decreased. The manganese concentration in the soil sample is very low as compared to permissible limit in normal and fertile soil for growing different crops,

Conclusion

The collected soil sample from the sampling site is degraded in nature and physico-chemical properties of the soil were very poor as compared to the normal fertile soil. Manganese concentration in the soil was also very poor as compared to normal soil. The deficiency of various essential minerals particularly manganese resulted in poor growth and production of cereals. The growth of different cereal crops in soil sample under controlled condition was very poor. The plant height of the plants was very poor. Enzymatic activity and reproductive yield were also influenced by soil nature and their physico-chemical characteristics.

Cereals are more sensitive against the deficiency and toxicity of Manganese available in soil. Deficiency of Manganese in cereals plants may result in 30-60 % reproductive yield loss. The productivity of cereals can be enhanced by the use of proper fertilizers and manganese application.

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