Indian J. Applied & Pure Bio. Vol. 41(3), 1772-1775 (2026). **ISSN: 0970-2091**

Comparative Biochemical and Antioxidant Responses of *Andrographis paniculata* (Burm. f.) Nees and *Solanum xanthocarpum* under Cadmium and Sodium Stress Schrad. & Wendl.

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Abstract

Two primary environmental stresses that have a major impact on plant development, metabolism, and productivity are salt and heavy metal contamination. Excess sodium (Naz) and cadmium (Cd) poisoning upset cellular homeostasis, cause oxidative stress, and produce reactive oxygen species (ROS) in plants. Although medicinal plants like *Solanum xanthocarpum* and *Andrographis* paniculata have significant therapeutic qualities, little is known about how they react physiologically and biochemically to abiotic stress. The goal of this study is to compare the biochemical and antioxidant reactions of these two species of medicinal plants under conditions of salt and cadmium stress.Numerous biochemical markers, including as protein levels, lipid peroxidation, and chlorophyll content, are changed by exposure to cadmium and sodium stress. Additionally, by producing more reactive oxygen species, these stresses exacerbate oxidative damage. Plants use their antioxidant defense systems, which include both non-enzymatic and enzymatic antioxidants like superoxide dismutase (SOD), catalase (CAT), and peroxidase (POD), to combat such stress. Comparative investigation indicates that the two species' varied levels of stress tolerance are caused by differences in antioxidant enzyme activity and biochemical modifications.These medicinal plants' adaptive responses and potential resistance under environmental stress circumstances can be better understood by comprehending the stress-induced biochemical and antioxidant pathways in these plants. In addition to increasing the pharmacological value of medicinal plants, this information may help improve their cultivation and conservation in contaminated or saline soils.

Key words : Oxidative Stress,Reactive Oxygen Species (ROS),Abiotic Stress.

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Andrographis paniculata (Burm. f.) Nees is a significant medicinal plant with bioactive substances such phenolics, flavonoids, and andrographolide that have antioxidant and therapeutic qualities[1].

According to Benavides *et al.*[6], heavy metal stress, such as cadmium poisoning, results in oxidative stress and a decrease in chlorophyll content, among other physiological and biochemical problems.

Cadmium buildup alters the activity of antioxidant enzymes including SOD, CAT, and POD while interfering with cellular metabolism and increasing lipid peroxidation[12].

Osmotic imbalance and ionic toxicity brought on by salinity stress from elevated sodium levels have an impact on plant metabolism and productivity[23].

Reactive oxygen species produced by abiotic stressors are detoxified by plants using their antioxidant defense mechanisms[4].

Alkaloids, flavonoids, and steroidal substances with potent pharmacological and antioxidant properties are found in Solanum xanthocarpum[19].

Enzymes like peroxidase, catalase, and superoxide dismutase are part of the antioxidant defense system and shield plants from oxidative damage[21].

Stress from the environment can affect how medicinal plants produce secondary metabolites[27].

According to Sharma *et al.*[29], comparative biochemical investigations aid in the understanding of plant species' stress tolerance systems.

Comprehending the molecular reactions of medicinal plants to heavy metal stress facilitates the assessment of tolerance mechanisms[15].

Growth is inhibited by cadmium's interference with photosynthesis, respiration, and nutrient intake[8].

Reactive oxygen species produced by cadmium can harm proteins, lipids, and nucleic acids[11].

Phytochelatins and increased antioxidant enzyme activity are two ways that plants detoxify heavy metals[9].

Osmotic stress and ionic toxicity brought on by salinity stress have a detrimental impact on metabolic processes[26].

Potassium uptake and cellular ionic equilibrium are disrupted by excess sodium[33].

In order for plants to adapt to environmental stress, antioxidant signaling is essential[10].

Due to their high phenolic and flavonoid contents, medicinal plants frequently exhibit robust antioxidant systems[18].

According to Verma and Shukla[32], environmental stress may increase the production of secondary metabolites in medicinal plants.

Diterpenoid lactones such andrographolide, which have antioxidant properties, are found in *Andrographis paniculata*[17].

Alkaloids and steroidal glycosides found in Solanum xanthocarpum are what give it its pharmacological characteristics[30].

Studies comparing plants show how different species cope with abiotic stress[14].

In plants, antioxidant enzymes including SOD, CAT, and POD aid in the detoxification of reactive oxygen species[29].

Plant development and productivity are negatively impacted by heavy metal contamination of the soil, such as cadmium[2].

According to Gupta *et al.*[13], cadmium lowers the production of chlorophyll and destroys the architecture of chloroplasts.

Malondialdehyde levels are frequently used to quantify increased lipid peroxidation under cadmium stress[16].

Plant development is restricted and water intake is decreased by high salinity[23].

Excess sodium hinders the absorption of vital nutrients including potassium and calcium[31].

By accumulating osmolytes and activating antioxidant enzymes, plants adjust to salinity[5].

One typical reaction to abiotic stressors is the production of reactive oxygen species[22].

Plants' glutathione and ascorbate systems have significant antioxidant functions[25].

Secondary metabolite formation in medicinal plants is frequently accelerated by stress[28].

Andrographis paniculata's antioxidant ability is mostly attributed to phenolic components[7].

Because of its flavonoids and alkaloids, Solanum xanthocarpum exhibits significant antioxidant potential[20].

Identification of stress-tolerant species appropriate for growth in contaminated soils is aided by comparative biochemical study of medicinal plants[3].

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