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Exploring the Anticancer Potential of *Achyranthes aspera* L.: A Traditional Remedy with Modern Applications

Baishnab Charan Muduli
ICAR-Central Rice Research Institute, Cuttack, Odisha
Utkal University, Bhubaneswar, Odisha

Abstract

Achyranthes aspera L. (Family: Amaranthacea), a medicinal plant widely used in traditional systems of medicine, has gained significant attention for its potential anticancer properties. This study aims to evaluate the antioxidant and anticancer activities of *Achyranthes aspera*, with particular emphasis on its free radical scavenging capacity using the DPPH assay. Which are associated with cytotoxic and antioxidant effects. In vitro antioxidant assays demonstrated a dose-dependent increase in DPPH radical scavenging activity, indicating the plant's ability to neutralize oxidative stress—a known contributor to cancer development. Additionally, previous studies have suggested the potential of *A. aspera* extracts to induce apoptosis and inhibit proliferation in various cancer cell lines. These findings support the ethnomedicinal use of *Achyranthes aspera* and highlight its potential role as a natural source of anticancer agents. Further in-depth pharmacological and molecular studies are warranted to isolate active constituents and understand their mechanisms of action.

Key words: Anticancer, *Achyranthes aspera*, Antioxidant, DDH

Rank	**Classification**
Kingdom	Plantae
Division	Magnoliophyta (Flowering plants)
Class	Magnoliopsida (Dicotyledons)
Order	Caryophyllales
Family	Amaranthaceae
Genus	*Achyranthes*
Species	*Achyranthes aspera*

Taxonomic classification:

Achyranthes aspera Linn., commonly known as "Apamarga" or "Prickly Chaff Flower", is a traditional medicinal plant widely used in Ayurveda and other traditional systems, has been extensively studied for its potential anticancer properties. Various extracts from this plant have demonstrated significant anti-proliferative and pro-apoptotic effects against different cancer cell lines, suggesting its promise as a natural therapeutic agent in cancer treatment (Subbarayan et al.,2012).

Achyranthes aspera L. isolated chemical compouns such as, Oleanolic acid, achyranthine, and betaine etc and the medicinal properties for cure diseases like, Stomach troubles, stones in the bladder, opacity of the cornea, wounds, piles, pneumonia, renal dropsy, leprosy, tetanus, gonorrhoea, and cancer. However, there are no recorded data for cytotoxicity against cancer cell lines and normal cell lines for these plants. Hence, in the present study, the plants were used for *in vitro* antioxidant, antiproliferative and anticancer activities in society.

Anti-Cancer Effects on Pancreatic Cancer:

Research has shown that methanolic leaf extracts of *Achyranthes aspera* exhibit time- and dose-dependent cytotoxicity against several tumor cells, anticancer potential across various cancer types, with a pronounced effect on Pancreatic cancer (PANC-1), Colon cancer (COLO-205), Breast cancer (MCF-7), Cervical cancer (HeLa) etc. The extract selectively suppresses the transcription of metalloproteases (MMP-1 and -2), tissue inhibitors of metalloproteases (TIMP-2), and angiogenic factors (VEGF-A and VEGF-B), indicating its potential to inhibit tumor metastasis and angiogenesis (Subbarayan et al.,2010:).

In vivo studies further support these findings. Administration of the leaf extract in athymic mice bearing human pancreatic tumor xenografts resulted in a significant reduction in tumor weight and volume. This effect is attributed to the induction of apoptosis through increased expression of caspase-3 and suppression of the pro-survival kinase Akt-1(Arora and Tandon 2014).

Table: Summary of Anticancer Properties of *Achyranthes aspera*.

Property	**Details**
Cytotoxicity	Active against multiple human cancer cell lines
Apoptosis Induction	Via mitochondrial and caspase pathways
Anti-angiogenic Activity	Downregulates VEGF and MMPs
In Vivo Tumor Reduction	Confirmed in mouse models
Nanoparticle-Mediated Delivery	Enhanced targeting and efficacy using AuNPs
Safe at Therapeutic Doses	Minimal observed toxicity in preclinical studies

Effects on Colon Cancer Cells:

Aqueous root extracts of Achyranthes aspera have demonstrated cytotoxic activity against human colon cancer COLO-205 cells. The extract induces apoptosis via the mitochondrial pathway and causes S phase cell cycle arrest. This is evidenced by increased expression of pro-apoptotic genes such as caspase-9, caspase-3, Bax, and cell cycle regulators p16, p21, and p27, along with decreased expression of the anti-apoptotic gene Bcl-2(Arora and Tandon 2014)

Antioxidant and Antiproliferative Potential:

The antioxidant properties of Achyranthes aspera contribute to its antiproliferative effects. Studies indicate that the hexane extract of the plant exhibits significant cytotoxic effects against various cancer cell lines, including AGS (gastric), MCF-7 (breast), A549 (lung), and COLO 320 DM (colon) cells, with minimal toxicity to normal VERO cells (Baskar et al.,2012).

Table: DPPH (2,2-diphenyl-1-picrylhydrazyl) assay of antioxidant activity of plant extracts, including *Achyranthes aspera*.

A. aspera L.	DPPH(µg/ml)
Hexane	953.16 ± 72.58
Ethyl acetate	613.10 ± 46.69
Methanol	753.13 ± 57.35

Green Synthesis of Gold Nanoparticles:

Innovative approaches have utilized Achyranthes aspera in the green synthesis of gold nanoparticles. Extracts from the seed-epicotyls layer of the plant facilitate the formation of gold nanoparticles, which exhibit potent anticancer activity against HeLa (cervical cancer) cell lines. This method offers an eco-friendly and efficient strategy for developing novel anticancer agents (Anand et al.,2014).

Conclusion:

The cumulative evidence highlights the remarkable anticancer potential of *Achyranthes aspera* across a range of cancer types. Its multifaceted mechanisms—including the induction of apoptosis, inhibition of cell proliferation, and cell cycle arrest are further supported by its strong antioxidant activity and emerging role in green nanoparticle synthesis. These properties collectively position *A. aspera* as a promising candidate in the development of natural, plant-based cancer therapeutics. However, to fully harness its clinical potential, further research is essential to isolate and characterize its active phytochemicals, as well as to validate their safety and efficacy through in vivo studies and clinical treatment for human society.

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Introduction:

Inadequate or erratic water availability causes water stress, which is one of the most serious environmental factors influencing agricultural output globally. The productivity and quality of leguminous crops, such as berseem, which are mostly farmed for feed, can be greatly decreased by water stress. Due to its pervasive production in areas with inadequate irrigation infrastructure, berseem is susceptible to fluctuations in water accessibility.

Critical markers of a plant's reaction to water stress include morphophysiological characteristics like plant height, leaf area, chlorophyll content, photosynthesis rate, and root growth. In the presence of scarce water, these characteristics change significantly, indicating both the direct and indirect effects on crop growth, development, and production. Knowing these differences can help find drought-tolerant cultivars and enhance water management techniques.

This article examines the morphophysiological responses of berseem to water stress and explores potential strategies to improve its drought tolerance.

Body

2.1 Responses of Berseem Plant Morphology to Water Stress: The berseem plant demonstrates various morphological adaptations in response to conditions of water stress, enabling it to manage decreased water availability.

Plant Height: Stunted growth resulting from water stress often ends in a decrease in plant height. This happens as a result of restricted water supply, which inhibits cell elongation and expansion—two processes necessary for vertical growth. Leaf Area: In an effort to conserve water and minimize transpiration, plants often respond to water stress by shrinking their leaf area. Smaller leaves can decrease photosynthesis through decreasing the surface area available for water loss. Root Development: Under water stress, berseem plants frequently show deeper root growth to optimize water intake. An adaptation mechanism called root elongation allows the plant to get to deeper soil layers that contain more moisture.

2.2 Physiological Alterations in Response to Water Stress: Berseem plants experience major physiological alterations as a result of water stress, which have an impact on their development and growth.

Chlorophyll Content: Photosynthesis is directly affected by water stress, which usually results in a decrease in chlorophyll content. Dehydration speeds up the breakdown of chlorophyll, thereby decreasing the plant's capacity to generate energy. Photosynthesis and Transpiration: Both photosynthesis and transpiration rates fall due to rising water stress. The plant's development and productivity are hampered by this decrease in photosynthetic activity. A significant reaction to water preservation is stomatal closure, which also blocks photosynthesis and diminishes CO2 consumption. Osmotic Adjustment: In order to preserve cellular turgor, plants that are under water stress frequently display osmotic adjustments. This entails the buildup of proline and other suitable solutes, which strengthens enzymes and cell structures in the face of dehydration.

2.3 Biochemical and Genetic Mechanisms: The ability of berseem cultivars to withstand water stress is significantly influenced by genetic variation. Certain types have certain characteristics that increase their resistance to drought, like:

Drought-Tolerant Varieties: In situations where water is restricted, some berseem cultivars have the capacity to sustain high yields. These types might use water more efficiently or have deeper root systems. Biochemical Routes: The biochemical pathway **Biochemical Pathways:** The production of antioxidants and osmoprotectants such glycine betaine and trehalose are examples of biochemical pathways that can shield plants from oxidative damage brought on by water shortage.

2.4 Effect of Water Stress on Berseem Yield and Quality: Berseem yield and nutritional quality can be significantly influenced by water stress. reduced forage yields result from fewer leaves and a reduced plant biomass when there are less water available. Furthermore, the forage's quality including its digestibility and protein content may be weakened.

Crude protein content, which is crucial for cattle nutrition, may decrease as a result of mild water stress, revealed to research. However, extreme water stress can cause the plant to suffer permanent damage and resulting in large output losses.

Conclusion:

The intricate interactions between plant growth, water availability, and environmental factors are demonstrated by the morphophysiological reactions of berseem to water stress. Gaining insight into these reactions is essential for creating plans to improve berseem's resistance to drought, especially in areas where water is scarce. Future studies ought to concentrate on finding and creating berseem cultivars with deeper root systems, greater drought tolerance mechanisms, and increased water-use efficiency. In addition, incorporating moisture-saving measures like efficient watering methods and soil moisture control could mitigate the negative effects of water stress on berseem output. In the face of growing water shortages brought on by climate change, berseem resistance can be increased by combining genetic and agronomic strategies.

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