AGRI MAGAZINE
(International E-Magazine for Agricultural Articles)
Volume: 03, Issue: 09 (September, 2026)
Available online at http://www.agrimagazine.in
©Agri Magazine, ISSN: 3048-8656

Impact of Elevated CO_2 on Growth and Development of *Amaranthus* Species

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As atmospheric carbon dioxide (CO_2) level is increasing continuously, to understand the response of the *Amaranthus* genus is essential. As it has dual role as a high-value "superfood" and a problematic agricultural weed. This article contains research on various *Amaranthus* species, including *A. tricolor*, *A. palmeri*, and *A. retroflexus*, to estimate their growth and development under increased CO_2 level and drought conditions. It indicates that elevated CO_2 acts as a physiological barrier, remarkably increasing biomass, height, and leaf area while reducing the adverse impacts of water scarcity. It also reveals that amaranthus adopts strategic adaptations measures, such as reducing stomatal density to conserve water and increasing antioxidant activity to neutralize oxidative stress.

Keywords: Amaranthus, elevated CO_2, biomass, drought tolerance, plant physiology

Introduction

In today world the concentration of CO_2 increases rapidly for which plants like Amaranthus are changing in unexpected way. Although Amaranthus is a tough plant that can handle heat, new research shows that increase in CO_2 actually helps it grow even faster and helps to stay stronger during droughts. By reducing the breathing pores on its leaves to save water and building up internal protective mechanism like antioxidants, Amaranthus can survive harsh weather that would kill other crops. While this physiological robustness is beneficial for crop production, it simultaneously creates a significant disadvantage for weed management. While it provides opportunities for climate smart superfood but it also creates weed problem that are increasingly taller, bulkier, and harder to control with traditional herbicides. This article focuses on the physiological and molecular mechanisms behind these responses to determine how the *Amaranthus* species will adapt to and potentially dominate the agricultural landscapes under high CO_2 level.

Impact of elevated CO_2 on Growth dynamic of *Amaranthus spp.*

With increase in CO_2 concentration there is total increase in dry matter production, root weight, and shoot weight of plant. There is increase in height, leaf area, stem weight and total volume compared to plant grows under normal condition. In early vegetative growth plant focuses mainly on shoot growth than the root growth.

Physiological effect

Under elevated CO_2 concentration there is increase in net photosynthetic rate as high external CO_2 concentration compensate for the reduced internal CO_2 caused by drought-induced stomatal closure. There is also increase in water use efficiency by reducing transpiration rate as stomatal frequency decreases and a partial closure of stomata, which helps the plant conserve water. So, it prevents excess water loss. Here plant show less cellular damage from drought induced oxidative stress as it showed lower electrolyte leakage or improved membrane integrity.

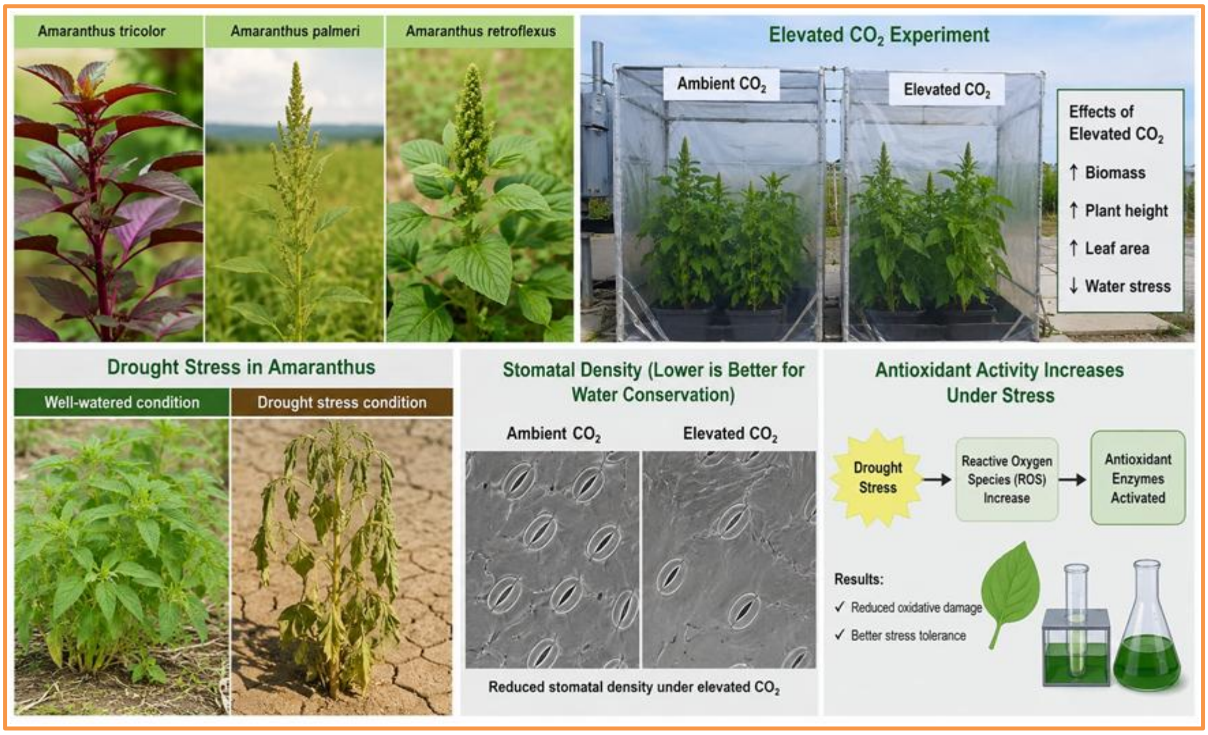

Fig 1. Growth and stress response of *Amaranthus* under elevated CO_2 and drought

Biochemical Defence Mechanisms

Increased in CO_2 act as protective mechanism. It increases phenol concentration and Superoxide Dismutase (SOD) activity under drought condition which act as a protective mechanism to neutralize reactive oxygen species (ROS) produced during drought. There was an accumulation of reducing sugars and free amino acids, which help in maintaining osmotic balance which maintain cell turgor. In Molecular level it maintains RuBISCO levels or activity more effectively than ambient conditions during stress which is a important part of C4 mechanism.

Drought tolerance and Recovery capacity

Elevated CO_2 (700ppm) act as a protective barrier against drought. It also helps in increase in plant resistance which leads to increase in growth under ambient CO_2 concentration during water scarcity. Plant grows under elevated CO_2 concentration show increase in recovery rate than normal plant. So amaranthus has a more flexible way of changing its physical structure in changing CO_2 levels.

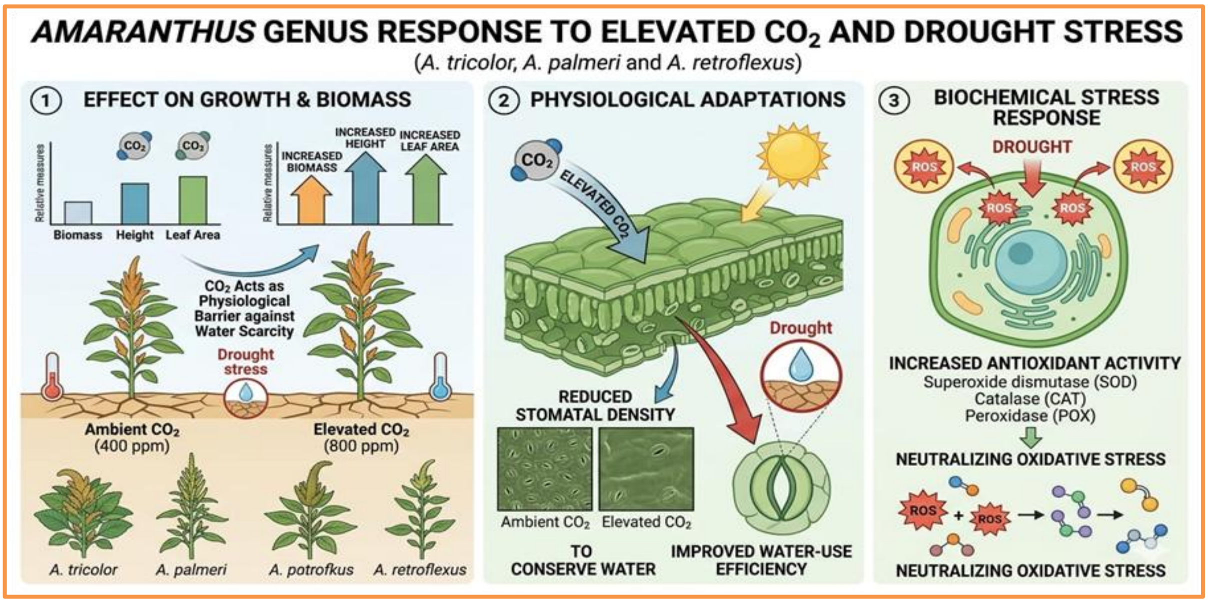

Fig 2. Morphological and physiological changes in Amaranthus under elevated CO_2

Management challenge

Increased in CO_2 level makes weeds grow faster and it is harder to kill with chemicals. Here amaranthus leaves develop a thicker waxy layer (cuticle) and fewer pores (stomata) which makes it physically harder for liquid herbicides like glyphosate to enter the leaf. It also increases the plant's metabolism which leads to break down herbicides before they can reach their target so effectively making the weeds to resistance the standard doses. Amaranthus is a good efficiator of C_4 pathway. In a future of high CO_2 and drought condition amaranthus grows faster while traditional crops slow down, giving the weed a greater competitive advantage for space, light, and nutrients.

Conclusion

In summary, increasing CO_2 levels act as a transformer for the Amaranthus plant. It shows that extra carbon dioxide acts like a defensive barrier for helping the plant to grow bigger and remain healthy even under water scarcity condition. By closing its leaf pores to save moisture and using internal chemicals to prevent damage, Amaranthus shows that it is one of the most resilient plants for a changing climate. However, it is a boon and blessing at a same time. While it makes Amaranthus a good climate proof food crop, it also makes Amaranthus weeds much more aggressive and harder for farmers to kill. So, by understanding these responses we have to develop future crop and weed management under changing climatic conditions.

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