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Role of AM Fungi on Growth and Yield of Foxtail Millet (Setaria italica) under Elevated CO_2

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ABSTRACT

Climate change accelerated events force scientists to develop alternative strategies to cope up the situation without affecting food security. Foxtail millet is a model C_4 plant, their properties such as drought tolerance, improved nutrient content with limited inputs makes this a potential crop for climate resilient studies. The C_4 metabolism, growth, physiology and development of foxtail millet under elevated CO_2 revealed that the yield can be improved with alterations in photosynthetic machinery. Further, the foxtail millet is drought tolerant; its potential of yield and under different water stress can be more beneficial. Moreover, from the literatures it can be evident that P and N nutrition supplementation enhances the drought tolerant capability of foxtail millet. Researchers across the globe has studied impact of elevated CO_2 on the growth physiology and nutrient quality of seeds of this model C_4 plant fox tail millet. However, microbial mediated climate smart agriculture is gaining momentum, research has sown AM fungi could tolerate and multiply on elevated CO_2 and increase yield of crops.

INTRODUCTION

The atmospheric concentration of CO_2 is likely to increase 1000 μmol mol^{-1} by the end of this century. An increased concentration of CO_2 can directly affect the growth, development, and yield of many crops. It has been observed that 19 and 16% increase in yield under eCO_2 of C_3 grain and legume crops respectively. This increment was due to down regulation of photosynthesis and light harvesting genes under eCO_2 with concomitant suppression of RUBISCO small subunit enzyme. In contrast, light fixation, defense and signalling were all up-regulated under eCO_2. One interesting fact related to eCO_2 is that it did not increase rather slightly decreased in yield was reported at eCO_2. Similarly, water stress alters physiology and growth of crops by decreasing leaf water potential and stomata opening, which further down-regulate photosynthesis-related genes and reduced availability of CO_2. Some of the alleviating mechanisms include enhanced production of defense related proteins and enzymes such as ROS, glutathione reductases etc.

Foxtail millet, ***Setaria italic,*** is a nutritious C_4 plant that is mostly grown in dry areas of Asia and has provided nourishment for many people in India, China, Korea, Japan, and Nepal. It is the second most widely grown millet after pearl millet, with China leading the way in terms of production (1.81 million tonnes from 0.72 million hectares during 2014). Because of its drought tolerance, the Foxtail millet was identified as an essential crop in rainfed areas in India. However, due to the advent of other cash crops in the 1990s, its area of cultivation decreased. In addition, awareness on alternative consumption of millets over cereals has been growing globally and owing to their nutritional importance, better growth at reduced water intake and tolerance to Climate makes this crop as a model C_4 plant for fundamental and applied research. Besides these the year 2022-2023 has been declared as International Year of Millets with the goal of promoting the multi-benefits of millets all over the world. Though there are several studies have proved that Foxtail millet can grow well under deficit water conditions, there are meager studies pertaining to growth and physiological effects of Foxtail millet under elevated CO_2. There are limited studies on Foxtail millet growth and physiology under elevated CO_2 coupled with water stress.

Arbuscular mycorrhizal fungi (AMF) are an endomycorrhizal fungus that is mutually associated with over 90% of terrestrial agricultural plants. It mobilizes phosphorus from distant sources and receives carbon from plant root exudates. Besides these benefits, AMF also confers disease and drought resistance to plants. In response to moisture stress fox tail millet develops rhizosheath under drought conditions, a soil moisture level of 10-14% resulted in gradual production rhizosheath compared to other moisture levels. Drought mitigation by microbial approaches in fox tail millet has also been investigated, with the conclusion that ACC deaminase-producing, plant growth-promoting rhizobacteria can help alleviate drought in fox tail millet (Niu et al., 2018). PEG induced drought stress in fox tail millet revealed involvement of phenyl proponoid pathway especially during germination process (Yu et al., 2020). According to a review of the literature, the main focus of worldwide research is on the effects of eCO_2 on foxtail millet growth, physiology, and nutritional quality. The abundance of metabolic genes, as well as their up and down regulation, were investigated. However, no studies performed coupled interaction of eCO_2 and water stress especially under the influence of AMF and their nutritional behavior. Therefore,

considering the importance of millets in day-to-day nutrition and their promoted benefits it is worth studying fact. Besides these, physiology and growth behavior and nutritional quality under eCO_2 coupled with moisture stress would pave the way for sustainable production of millets under growing climate.

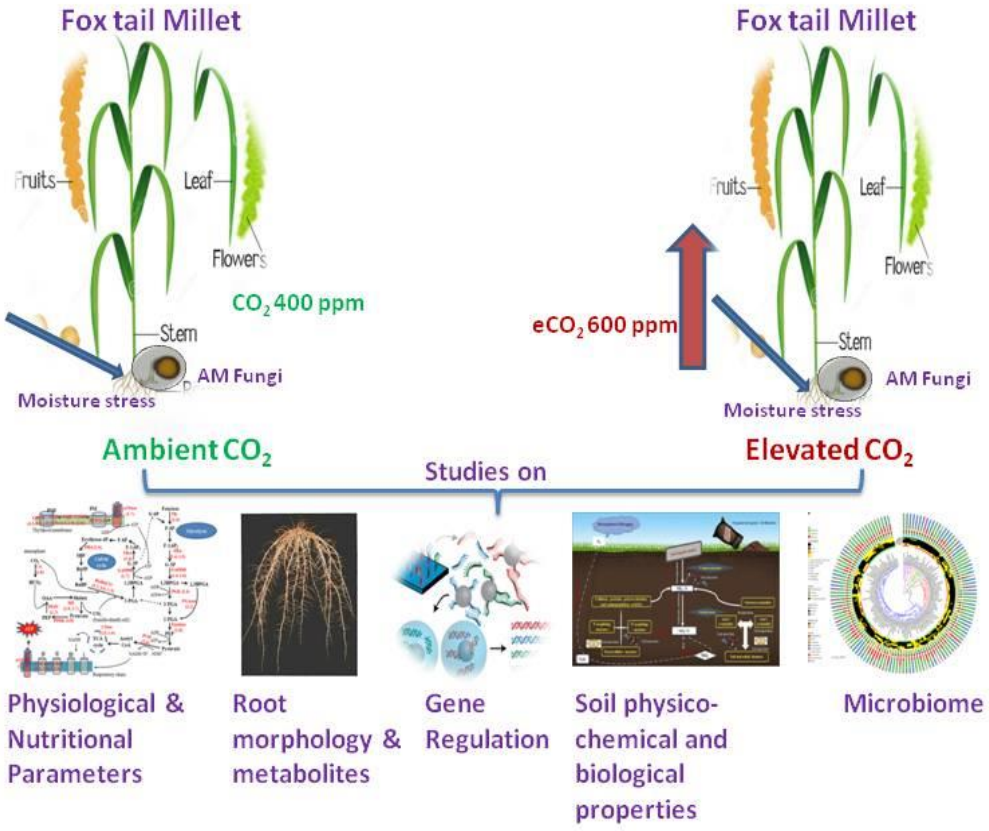

Figure 1. Overview of the AM fungi interaction in foxtail millet

CONCLUSION

AM fungi can be utilized as bio-inoculant in drought prone areas for yield improvement of millets. Even if the CO_2 concentration increases by 2030 this AM fungi would serve as the potential ameliorating agent of climate change of millets without affecting the nutritional quality of millets.