# THE ROLE OF DEFENSIVE PHYTOCHEMICALS PROMOTE STRESS RESISTANCE IN MAIZE (*Zea mays* L.) ACCESSIONS

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## 1. INTRODUCTION

Maize (*Zea mays* L.; 2n=2x=20), a typical C4 plant belonging to the family Poaceae, is substantially contributing to the world's food and feed demand (Lana *et al*., 2017). This crop confers improved efficiencies in utilizing water, nutrient, and solar radiation compared to conventional C3 plants, such as rice, wheat, and barley (Ghannoum *et al*., 2010). In Sri Lanka, maize is commonly grown in the dry and intermediate zones as rain-fed cultivation during the *Maha* season. Two-thirds of the country's agricultural lands are located in a dry zone extending in the north, north-central, eastern, and southeast parts of the country whereas, Eastern Province has significantly higher maize productivity than other parts (Williams *et al*., 2018). Owing to this reason, maize cultivation is becoming more popular and large-scale cultivation is undertaken employing hybrid seeds, as such contributing 25 % of the country's annual maize production (Thadshayini *et al*., 2020).

Since a large extent of maize cultivation depends on rainfall, drought becomes a key limiting factor for its productivity (Barton and Clark, 2014). About a quarter portion of the maize cultivation is affected annually by drought and heatwaves caused to increasing atmospheric temperatures triggered due to the global climate change that has immensely contributed to seasonal variations and weather patterns (Manavalan *et al*., 2011). The predicted climatic changes is expected to decrease the rainfall by 34 % in 2050 as such raise the atmospheric temperature by 1.6 $^{o}$C (Thadshayini *et al*., 2020). This alarming situation might pose a serious threat to Sri Lankan maize production, particularly in the Eastern Province.

Plants have a natural tendency and possess defense mechanisms to dilute the effects of rising temperature and water deficit. In this perspective, drought influences the biochemical and physiological metabolic activity of the maize resulting in osmotic stress. Further, it is clear that the plant's responses to drought stress vary significantly depending on plant species and developmental stage, and severity of the interacting stress stimuli (Ahanger *et al*., 2016). In order to mitigate such adverse situations within the ultracellular environment, maize plants have evolved a well-developed phytochemical defense mechanism modulating a variety of resilience compounds such as proteins, flavonoids, and lignin-like cell wall components to protect the plant tissues (Vaughan *et al*., 2018). Therefore, the objectives of this report are to elaborate on the types of protective phytochemicals triggered by drought that enables maize plants to withstand stress while allowing plants to maintain substantial biomass and grain yield.

## 2. RESULTS AND DISCUSSION

Different types of protective phytochemicals are produced in maize under drought conditions depending on the tissue type and developmental stage in order to protect plants above and below-ground tissues. In this review, we will focus on benzoxazinoids, volatile organic compounds, and terpenoid phytoalexins synthesis when maize plants are exposed to drought.

**Benzoxazinoids**

Benzoxazinoids are the most extensively studied phytochemicals that are directly related to the defense mechanism in maize (PGRFA, 2007). They consist of nitrogen and accumulate as glucosides in younger tissues (Wouters *et al*., 2016). The composition and concentration of benzoxazinoids vary with maize genotype, age, organ, and weather conditions (Niemeyer, 2009). The growth and development rate of maize increase with warmer temperature leading to high benzoxazinoids content in seedling tissues and starts to decline with plant maturity (Cambier *et al*., 2000). Erb *et al*. (2009) demonstrated that the condition of drought that restricts the maize growth increases the total benzoxazinoids accumulation in maize leaves. Since it is a nitrogen-containing metabolite, the production potential is dependent on soil nitrogen availability as well (Brevik, 2013). Hence, it is important to make sure that the maize field is well-fertilized.

**Volatile organic compounds (VOCs)**

Volatile organic compounds produced in maize are structurally diverse and include multiple terpenoids, indole, and C6 green leaf volatiles (GLVs) (Vaughan *et al*., 2018). According to Degen *et al*. (2012), there is high variability in the composition and quantity of constitutive and inducible VOCs produced by different maize cultivars and lines. Specific volatiles are constitutively emitted at a low level in maize, however, some specific mixtures are induced by different stress conditions. In addition to the temperature, VOC production in maize is found to be influenced by soil moisture, air humidity, and light intensity. Gouinguene and Turlings, (2002) found out that volatile emissions from young maize leaves were greatest at 60 % relative air humidity and between 22 and 27 $^{o}$C. They further concluded that the relative abundance of individual volatile compounds varied at different temperatures. Like in benzoxazinoids, soil infertility reduces the VOC production in maize also (Vaughan *et al*., 2018).

**Terpenoid phytoalexins**

To date, scientists have discovered two classes of maize terpenoid phytoalexins that are zealexin and kauralexin (Schmelz *et al*., 2014). The abundance of these terpenoid phytoalexins varies based on the type of stress (Huffaker *et al*., 2011b). According to Vaughan *et al*. (2018), kauralexin are predominately produced in maize roots compared to zealexin during drought conditions.

**Implications of this study**

The synthesis of photoprotective chemicals such as benzoxazinoids, volatile organic compounds, and terpenoid phytoalexins exerts greater control in plant growth and development when maize plants are exposed to drought. However, the level of such chemical synthesis at ultracellular levels depends on the existence of natural variations among maize germplasms, growth stages, and the exposure level to stress. However, it is interesting to note that there are 697 maize germplasm accessions in Sri Lanka, with 35 of them being classified as landraces (PGRFA, 2007). Therefore, a systematic screening process is required for a better understanding of the synthesis of photoprotective chemicals among local maize accessions, and to select the elite germplasms for advanced plant breeding programmes. As such, this will pave the way to develop new cultivars possessed with optimal plant resilience and productivity in the face of combined biotic and abiotic stresses

## 3. CONCLUSIONS

Sustainable efforts are crucial in maize production in order to ensure global food security under various stress conditions due to the rapidly changing climatic conditions. Defensive phytochemicals synthesized in maize plants play a significant role in stress resistance and resilience. Moreover, the defense response efficiency is proved to be dependent on plant species, nature, timing, and the degree of the interacting stress stimuli as well. Hence, a clear understanding of the synthesis and accumulation of diverse defense phytochemicals among Sri Lankan maize landraces in temporal and spatial contexts will be helpful for future crop breeding programs.

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