Response of plants of the fabaceae family caused by different types of abiotic stress

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ABSTRACT
Abiotic stresses have a negative impact on the productivity and survival of plants throughout the world, including agricultural crops. Currently climatic conditions such as drought, extreme temperatures and sources of pollution that deteriorate the soil and water have increased greatly. Plants have developed molecular, morphological and physiological mechanisms in order to counteract various types of stress, both biotic and abiotic. Knowing mechanisms like these help to implement conservation and genetic improvement strategies in plants, useful both for the agricultural sector and in bioremediation. Therefore, this work seeks to demonstrate the effect of abiotic stress on Fabaceae, by comparing different parameters studied in 10 plant species of the Fabaceae family.

Keywords: abiotic stress, fabaceas, bioremediation, agriculture.
1 INTRODUCTION

Plant responses to the environment are highly diverse and occur at the molecular, metabolic, cellular, physiological, and morphological levels and are controlled by highly complex signaling and regulatory processes. Phenotypic plasticity is one of the most common expressions of plant reaction to stress, especially abiotic stress, and is produced as a result of an interaction between the aerial part (stem) and the roots through a complex endogenous signal transmission system (Ascencio, 2005).

The availability of water and nutrients, the factors that impose a water deficit (temperature, insolation, salinity), as well as the contaminants present in the environment, limit plant growth and productivity. Drought, salinity and dehydration due to low temperatures constitute a direct source of osmotic stress, while freezing and hypoxia also contribute indirectly to said stress, because they influence the uptake and loss of water (Benítez, 2005).

For a response to stress to occur, plants must have the ability to recognize it; this involves the perception of the stimulus (stressor) that activates the signaling pathway and construction of the response, for the transmission of information in individual cells throughout the entire plant. In the final phase, the changes in gene expression that occur at the cellular level are integrated into a global response of the plant that could modify its growth and development and even its reproductive pattern and capacity (Ascencio, 2005).

Legumes belonging to the Fabaceae family are consumed worldwide, they are rich in proteins, vitamins and minerals and add volume to the diet; Due to its nutritional profile, its daily intake can help reduce micronutrient deficiencies among people in developing countries. Legumes have a prospective role in conservative agriculture due to their ability to fix atmospheric nitrogen (N), which improves soil fertility (Singh et al., 2021).

2 MATERIALS AND METHODS

2.1 SEARCH AND ANALYSIS OF DATA OBTAINED

A literature search was carried out and a minimum of 10 different plants of the Fabaceae family were taken as a search parameter. The data was processed with the Plantico package available for download through the R programming language (Quintana et al., 2021)

3 RESULTS

The different types of studies involving abiotic stress in the Fabaceae family for the 10 selected plants are shown in Table 1. They can be observed in different phases of plant growth including from seed germination.
<table>
<thead>
<tr>
<th>Plant (scientific name)</th>
<th>Type of stress induced</th>
<th>Type of study that was carried out</th>
<th>Parameters studied</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cicer arietinum</em></td>
<td>Toxic heavy metal (Cd) stress</td>
<td>Field study during different reproductive phases of the plant (Baweja <em>et al</em>., 2020).</td>
<td>Biochemical and morphological parameters such as % germination, chlorophyll pigments, total proteins, phenols, lipids and carbohydrates.</td>
</tr>
<tr>
<td><em>Glycine max</em></td>
<td>Salt stress</td>
<td>Field study of plant development under different concentrations of NaCl (Amirjani, 2010; Azarafshan &amp; Abbaspour, 2014).</td>
<td>Biochemical and morphological parameters such as proline accumulation, diamine oxidase, ion concentration, growth and dry weight variation.</td>
</tr>
<tr>
<td><em>Lotus corniculatus</em></td>
<td>Salt stress</td>
<td>Hydroponic culture with different concentrations of NaCl (Amirjani, 2010; Azarafshan &amp; Abbaspour, 2014).</td>
<td>Analysis of the content of proline, glycine betaine, soluble sugars and Na+ and Cl- ions.</td>
</tr>
<tr>
<td><em>Vigna unguiculata</em></td>
<td>Hydric stress</td>
<td>Field study with water supply as a limiting factor (Cardona <em>et al</em>., 2014).</td>
<td>CAT activity, APX. Quantification of proline, chlorophyll, carotenoids.</td>
</tr>
<tr>
<td><em>Arachis hypogaea L</em></td>
<td>Hydric stress</td>
<td>Study in germinated seeds in vitro (Akçay <em>et al</em>., 2010).</td>
<td>Changes in the content of MDA, H2O2 and proline, and in the enzymatic activity of APX, CAT, POX and GR.</td>
</tr>
<tr>
<td><em>Erythrina velutina</em></td>
<td>Salt, hydric and thermal stress</td>
<td>Study in germinated seeds in vitro (Sena, 2017).</td>
<td>Morphological parameters as % of seed germination.</td>
</tr>
<tr>
<td><em>Ceratonia siliqua L</em></td>
<td>Salt stress</td>
<td>Field study of plant development under different concentrations of NaCl (El Kahkahi <em>et al</em>., 2015).</td>
<td>Content of chlorophyll, proline and sugars.</td>
</tr>
<tr>
<td><em>Vicia faba</em></td>
<td>Salt stress</td>
<td>Study and comparison of the development of varieties of the plant species under different concentrations of NaCl (Abdelhamid, 2013).</td>
<td>Analysis and contrast of the content of total sugars, total free amino acids, proline, oxidative enzymes, mineral concentration and seed yield.</td>
</tr>
<tr>
<td><em>Phaseolus vulgaris L</em></td>
<td>Stress due to toxic heavy metal Cadmium (Cd)</td>
<td>Study on germinated seeds in vitro as well as on seedlings (Añazco, 2019).</td>
<td>Tolerance and phytotoxicity index, % germination, and seedling growth.</td>
</tr>
<tr>
<td><em>Lens culinaris</em></td>
<td>Stress due to toxic heavy metal Cadmium (Cd)</td>
<td>Study on germinated seeds in vitro as well as on seedlings (Añazco, 2019).</td>
<td>Tolerance and phytotoxicity index, % germination, and seedling growth.</td>
</tr>
</tbody>
</table>

It is observed that both in the *G. max* species and in the salt-stress resistant variety of *L. corniculatus*, the accumulation of proline in the tissues increases in the presence of NaCl, with an increase in concentration of up to 20 times in the highest concentrations of NaCl. for *G. max*, and duplicating in *L.*
corniculatus (Amirjani, 2010; Azarafshan & Abbaspour, 2014). This increase was also observed in the study carried out with V. faba (Abdelhamid, 2013). On the other hand, in the study carried out with different C. siliqua varieties, it was observed that the plants with less tolerance to NaCl presented greater proline accumulation, while those that were more susceptible to saline stress presented less proline accumulation (El Kahkahi et al., 2015). This is a commonly observed result in these types of studies. Plants are able to tolerate salinity stress due to osmotic mechanisms to maintain their water content through the accumulation of metabolites such as proline, soluble sugars and some ions. Therefore, under salt stress, proline acts as a protective molecule (Bray, 2000).

Another factor studied is the morphological effect generated by saline stress. For this case, a reduction in height of up to 76% was observed in the study carried out with Glycine max (Amirjani, 2010; Azarafshan & Abbaspour, 2014). Similar results were obtained with C. siliqua, where a reduction in the elongation of the stem and the root system of the plant of 4 and 8 cm, respectively, was observed (El Kahkahi et al., 2015). With E. velutina, it was shown that the increase in the concentration of sodium chloride had a negative influence on the germination percentage of the seeds, reaching only 30% with a concentration of 48 d.Sm-1 (Sena, 2017).

When making comparisons between studies of water stress generated by drought, it is observed that for V. unguiculata, there is a reduction in grain, pod and seed yield of 57, 39 and 42%, respectively. On the other hand, in E. velutina seeds, subjected to different osmotic potentials, a reduction in dry weight has been observed, mainly in the stem compared to the roots (Cardona et al., 2014). In a similar study carried out with the species A. hypogaea, it was found that the variety of this species that has less tolerance to drought obtained a reduction in dry weight of almost 50% (Akay et al., 2010). The main signal caused by drought is hyperosmotic stress, which is often simply called osmotic stress because a hypoosmotic condition is generally not a major problem for plant cells. Salt stress has both osmotic and ionic or ionic toxicity effects on cells. Secondary effects of drought and salt stress are complex and include oxidative stress; damage to cellular components such as membrane lipids, proteins, and nucleic acids; and metabolic dysfunction. While some cellular responses result from primary stress signals, others arise primarily from secondary signals (Zhu, 2016).

Regarding the thermal stress induced in E. velutina seeds, germination has been observed in a wide temperature range, indicating that the temperatures in which there was no germination were at 5, 40 and 45 °C, concluding that the optimal germination range it is 25 to 30 °C (Sena, 2017).

On the other hand, in studies carried out to determine tolerance to Cd stress, the species Cicer arietinum was affected by the toxicity of said metal, generating a reduction of up to 10% in seed germination. A negative effect was also observed on the growth of the stem and roots of the species, with
length decreases of 77 and 84%, respectively (Baweja et al., 2020). In another study with seeds of *Lens culinaris* (Lentil), *Oryza Sativa* L. (Rice) and *Phaseolus vulgaris* L. (Bean), they were exposed to different concentrations of Cd, from 0.25 to 8 mg/L. Both the bean and the lentil presented a final germination percentage of 43 and 38 %, respectively, at high concentrations. However, for rice, 93% final germination was reported at 8 mg/L. The analysis in this same study showed great effects of cadmium on the length of the radicles, even at low concentrations (Añazco, 2019). Although plants require certain metals for their growth and development, excess metals generate toxicity, leading to adverse effects on their growth. Cd in particular is not an essential element for plants, and negatively affects their development, since it affects the availability of minerals in the soil, which in turn prevents plants from taking essential minerals for their correct development. On the other hand, the excess of Cd in the soil also generates the reduction of the microbiome, which also negatively affects the development of plants (Wang et al., 2009).

More attention needs to be paid to plant responses to multiple simultaneous abiotic stresses and to the crosstalk between abiotic and biotic stress signaling because much of the research on abiotic stress to date has been conducted on sterile plants grown in culture media in the laboratory. In nature, however, plants coexist with insects and microorganisms (Zhu, 2016). These types of studies have great relevance, especially in the agronomic sector and it is for this reason that the focus of studies with salinity stress (Fig. 1), the impact of the different types of abiotic stress on vegetation must be known in order to generate mechanisms that increase the resistance of plants to these stress situations, avoiding large losses, due to poor performance. On the other hand, knowing the species with greater tolerance to certain types of stress also makes it possible to find plants with potential for phytoremediation processes.

![Figure 1: Distribution of the type of stress according to the selected studies](image-url)
4 CONCLUSIONS

The plants respond to the stimulus of the abiotic factor presenting different results. The accumulation of proline in the tissues increases in the different species compared when they are under salinity stress. The same is observed in the morphological effects generated by hydric stress, in which all the compared species suffer negative effects in the development of the root system, aerial and a decrease in seed germination. The stress generated by the heavy metal Cadmium also has the same adverse effects on the development of the different species.
REFERENCES


