Overexpression of the AtDREB1A gene in almonds with respect to drought tolerance

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Abstract

One class of transcription factors is the dehydration-responsive-element-binding proteins (DREBs), which can be increased when a plant detects that it is under water deficit conditions. The DREBs, which belong to the group of ethylene responsive factors (ERF), are involved in the regulation of signal transduction pathways under low temperature, salinity and dehydration conditions. One type of DREB is AtDREB1A which has been tested in many different crops, including tomatoes, peanuts, potatoes, and rice. The results have been promising when AtDREB1A was expressed in other crops. Proline contents were increased, ABA levels were kept under normal conditions, and Reactive Oxygen Species levels were decreased. Due to the success of AtDREB1A in other crops, it worth the investment to test the effects AtDREB1A would have in Almonds because the likelihood of success is high.

Intro

Over the past century, California's almond production has greatly increased and now, the state is responsible for approximately 80% of the world's almond production (Rankin, 2014). Almond sales to contribute nearly $11 billion in value to the California economy every year (Sumner et al., 2013). However, the main factor causing high production costs for almonds is the amount of water they require to grow. In order to grow 1 almond, it takes 1.1 gallons of water, and to grow 1 pound of almonds, it takes around 1900 gallons (Kogon, 2016).

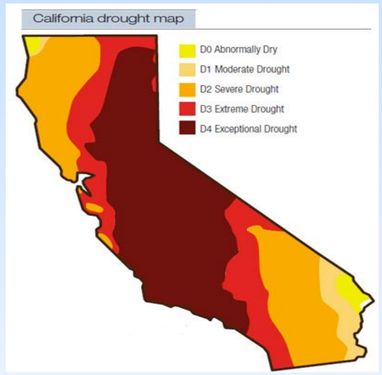

Figure 1. Map of California's drought in 2015

The DREBs, which belong to the group of ethylene responsive factors (ERF), are involved in the regulation of signal transduction pathways under low temperature, salinity and dehydration conditions (Sarkar et al., 2014). DREB proteins are transcription factors which have a significant role in inducing the expression of many abiotic stress-inducible genes. The DREB or CBF (C-repeat binding factor) family of transcription factors, are a subgroup of the APETALA2(AP2)/ethylene-responsive factor (ERF) family, which is composed of a total of six subgroups (A-1 to A-6)on the basis of their gene structure (Dong et al., 2017).

Research Question

Will the overexpression of the ATDREB1A gene in other plants show a significant change in drought tolerance to offer viable reasoning for further studies in Almonds?

Hypothesis

Altnerate: It is worth the investment to overexpress AtDREB1A in almonds because of reported success in other species.

Null: The effects of overexpressing AtDREB1A in model species indicate little support of applying the treatment to almonds.

Purpose

Currently, almonds require a large amount of water in order to grow, and most of the world's almonds are grown in California. In a state that frequently has droughts and is experiencing rising water costs, it is important to reduce the amount of water consumed by almonds in order to decrease production costs.

To determine the effect AtDREB1A will have on almonds, the effect AtDREB1A has had on other crops drought tolerance must be analyzed. Then it must be concluded whether or not that same effect would occur in almonds

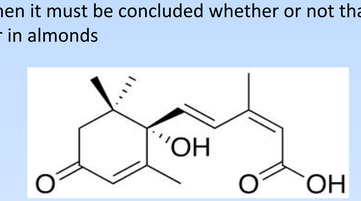

Figure 2. Structure of ABA Acid

Methods

The research design for this project was systematic literature review. Many different peer reviewed papers were used to gather and data. Peer reviewed papers were obtained from Ebscohost, the library database at Cal State Channel Islands University (CSUCI), the online database of University California at Santa Barbara (UCSB), the National Center for Biotechnical Information (NCBI), and the Almond Board of California. Finding literature concerning the effects of almonds on the California economy was not difficult. As for finding literature relating to AtDREBA, there were plenty of papers, but many of them did not have data which could be related to other papers data.

The crops used for data were peanuts, tomatoes, potatoes, and rice. Data that was obtained about the crops, regarded any of the following: Relative Expression (Fold Increase) of AtDREBA, Hydrogen Peroxide Concentration, or Proline Content. Although more data was given in papers, that same data could not be found in other papers, which meant it couldn't be accepted.

In order to determine the validity of the data, multiple T-Tests were performed. P values were calculated and based on the P value, the data was either accepted or rejected.

Results

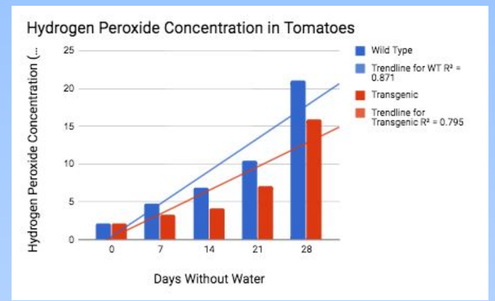

Figure 3A. Displays the Hydrogen Peroxide Concentration (m mol/g) 0 days (well watered), 7 days, 14 days, 21 days, and 28 days after being restricted of water. WT are non-transformed plants while transgenic plants are overexpressing AtDREB1A . P value= 0.000465

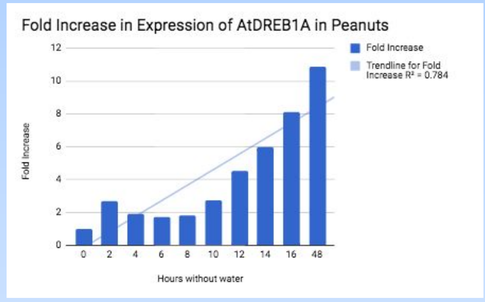

Figure 3B. Displays fold increase of the overexpression of AtDBRB1A in peanuts after 0 (well watered), 2, 4, 6, 8, 10, 12, 14, 16, and 48 hours of being deprived of water. P value= 0.002

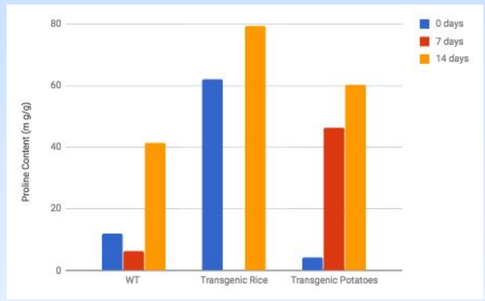

Figure 3C. Displays the proline content (m g/g) in wild type plants, transgenic rice overexpressing AtDREB1A, and transgenic potatoes overexpressing AtDREB1A. Values were taken after 0 (well watered), 7, and 14 days of water deprivation. No value was available for transgenic rice at 7 hours. P value= 0.201

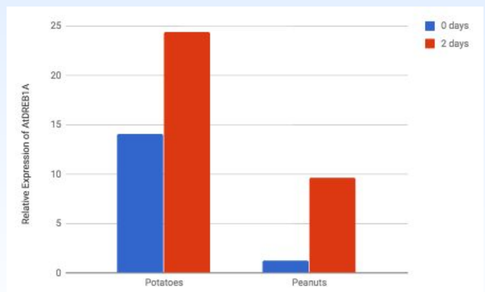

Figure 3D. Displays the Relative Expression (Fold Increase) of AtDREB1A in peanuts and potatoes after 0 days (well watered) and 2 days of being deprived of water. P value= 0.221

Discussion

Data analysis of results show that there is a correlation between the overexpression of AtDREB1A and improved drought tolerance. In figure 3A, the hydrogen peroxide concentration was shown to be much lower in transgenic lines as compared to wild type plants. This is significant because although hydrogen peroxide production is good initially for regulating vital processes, overproduction can be detrimental to the plant.

In peanuts (Figure 3B), similar results were found. In figure 3B, it is seen that engineers were able to successfully overexpress AtDREB1A. This is important because it shows that overexpression was successful in another crop that is in a different family. Peanuts are in the *Legumes* family, while tomatoes belong to the *Nightshade* family. This means that the transcription factor has been successful in multiple families and is not just limited to one type of family, thus increasing the probability of it being successfully expressed in other families.

In addition, rice is from the *Gramineae* family and potatoes are also from the *Nightshade* family. The successful overexpression in rice though is important because it is yet another family that overexpressed AtDREB1A.

All of this research and data in other crops is important because it adds validity to the hypothesis that almonds will successfully overexpress AtDREB1A. AtDREB1A has proven that it can be effective in multiple different types of crops, even if they are in different families. There's no reason to believe that overexpressing it in almonds, which are in the *Rosaceae* family wouldn't be successful because there have been many experiments done where scientists found extremely positive results.

Conclusion

In conclusion, it is worth the investment to research the effect AtDREB1A would have in almonds. AtDREB1A has proven to be successful in many different types of families, which means the probability of success in almonds is relatively high. If successful, almonds would require much less water to grow and California exports would increase due to higher crop yields.

Further Work

Much more work still needs to be done in relation to AtDREB1A. More tests and research should be performed in order to validate results. In addition, tests should be done in different crops to maximize the potential of AtDREB1A. Finally, most tests performed were in labs, but in order to make sure results would tranfer to a natural environment, more field tests should be done.

References

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