Water Deficits and Yield in Maize: Functional Reversion of Floral Abortion

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Problem

Water deficits cause floral abortion in crops

Water deficits affect expression of most genes

Which genes control abortion?
Drought of 1988 in Lewes, DE

50% height

15% kernels
Maize Life Cycle

Vegetative

0 40 100 days

Reproductive

Meiosis  Pollination

Abortion window
Supplying Sucrose During Water Limitation

Infuse sucrose here on first day

Withhold water for five days
Only a Few Days of Low Water Potential and Low Photosynthesis Trigger Abortion

Functional Reversion

Conclusion from Field/Lab Work

Sucrose fed to parent in photosynthetic quantity prevents abortion

What physiology/biochemistry causes abortion?
Photosynthesis Supplies Mostly Sucrose to the Ovaries, Which Hydrolyze It With Acid Invertase

Sucrose $\rightarrow$ Acid invertase $\rightarrow$ Glu $\rightarrow$ Starch $\rightarrow$ Fru
Sucrose Delivery to Ovary

Ovary Invertase in Cell Wall

Control

Low $\Psi_w$ + Sucrose Feeding

Low $\Psi_w$


Ovary Glucose

Control

Low $\Psi_w$ + Sucrose Feeding

Low $\Psi_w$

Ovary Starch

Control

Low $\Psi_w +$ Sucrose Feeding

Low $\Psi_w$

Low Sucrose Delivery + Partial Block of Invertase

Sucrose \xrightarrow{\text{Cell Wall Acid}} \text{Invertase} \xrightarrow{\text{Glu}} \xrightarrow{\text{Fru}} \text{Starch}
Summary

Lack of photosynthesis starves female floret, causing abortion after starch is depleted

Do florets simply starve, or is active gene regulation also involved?
mRNA Abundance for Ovary Genes for Cell Wall Acid Invertase

Ovary mRNA’s for Senescence Enzymes

Sugar-Responsive

Does Senescence Occur?

Evans Blue Stain for Loss in Membrane Integrity

Control

Low $\Psi_w +$ Sucrose Infusion

Low $\Psi_w$

Low $\Psi_w$ (magnified)

Stain

SUMMARY

Summary

Around the time of flowering in maize,

hundreds of genes change expression when water becomes limited

among the hundreds of genes, functional reversion identified four controlling ovary abortion

the four included senescence genes that responded to sugar supply, probably glucose

irreversibility required a few days to deplete the sugars that triggered the senescence genes
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