Heat stress inhibits kernel sugar transport via mitochondrial developmental defects

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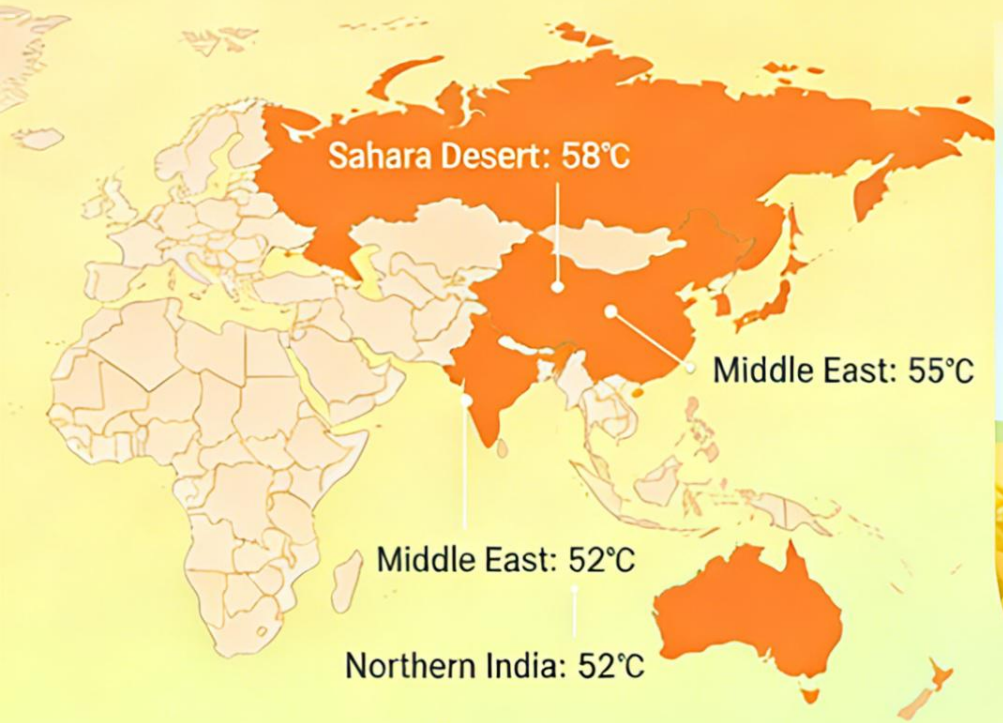
2025 Global Extreme High Temperature Data Report



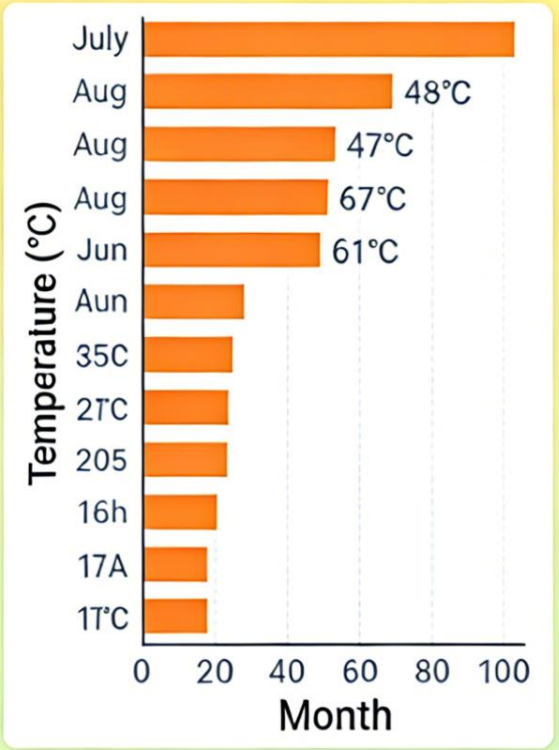
National summer grain output this year

146.13 million tons

Down 0.9%

from last year

Although this year's summer grain output hes slightly decreased, it is still at a relatively high level



According to the Ministry of Water Resources on July 25, the current national arid farmland area is

20.82 million mu

Lighter than the same period in previous years

Persistent high temperatures have a certain impact on grain production in some areas, but it is relatively limited

Kansas winter wheat production Expected to decrease by year-on-year 22%

Spain wheat production Expected to be 38% lower than 5-year average

Australia wheat production Expected to decline this year 34%

Annual High Temperature Extreme Changes

Previous research

Mechanisms underlying kernel filling

Sink

Aleurone layer

Starchy endosperm

Embryo

Capacity maximum potential storage capacity

Number and volume of endosperm cells

Kernel volume and surface area

Division and proliferation of endosperm cells

Activity uptake, convert and accumulate assimilates

Energy metabolism, mitochondrial function and ROS homeostasis

Flow

Embryo surrounding region

Basal endosperm transfer layer

Placenta-chalaza

Structure

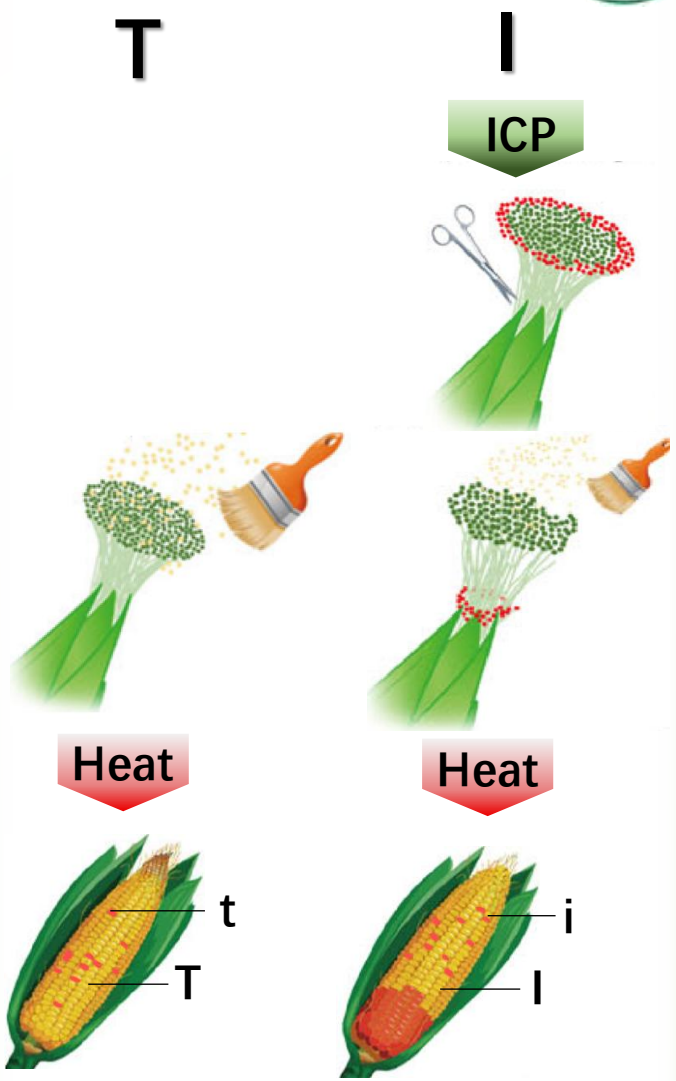
Pedicel → Rachi → VB → PC → BETL → EN / EM

Activity assimilate loading, unloading & partitioning

Kernel unloading capacity

Energy supply and signal regulation

Sucrose transporters



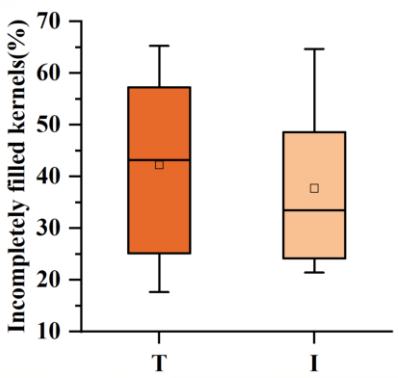
Shen S, Liang XG, Zhang L, Zhao X, Liu YP, Lin S, Gao Z, Wang P, Wang ZM, Zhou SL. Intervening in sibling competition for assimilates by controlled pollination prevents seed abortion under postpollination drought in maize. Plant Cell Environ. 2020 Apr;43(4):903-919.

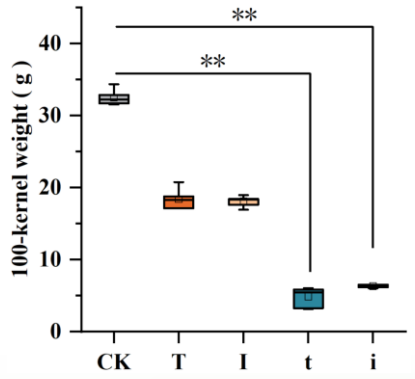
Result 1 Heat stress inhibits grain filling and inhibits kernel development

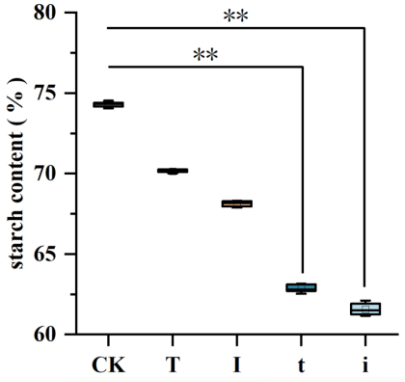
Incomplete filling is independent of sugar availability

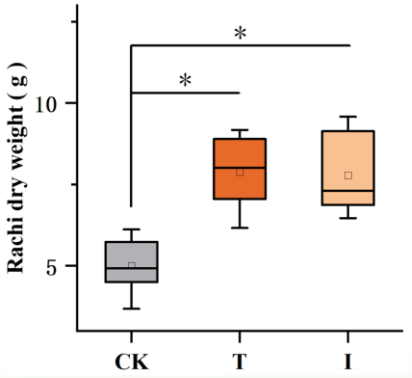
Assimilates accumulate in the maize cob pedicel

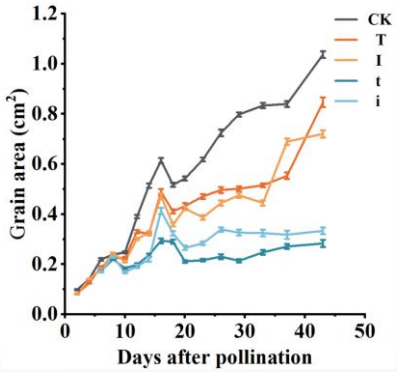
Premature arrest of kernel growth



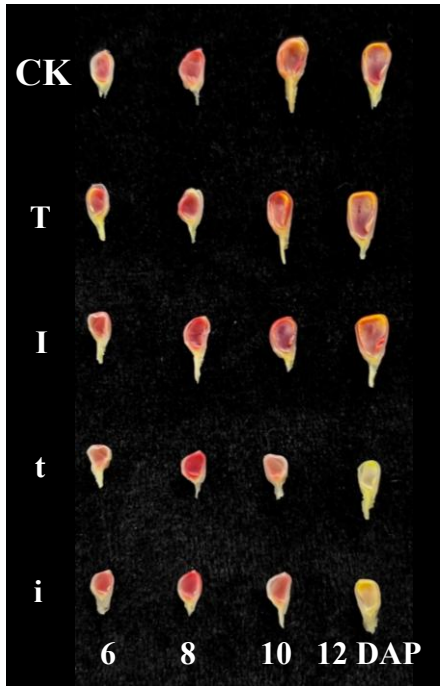


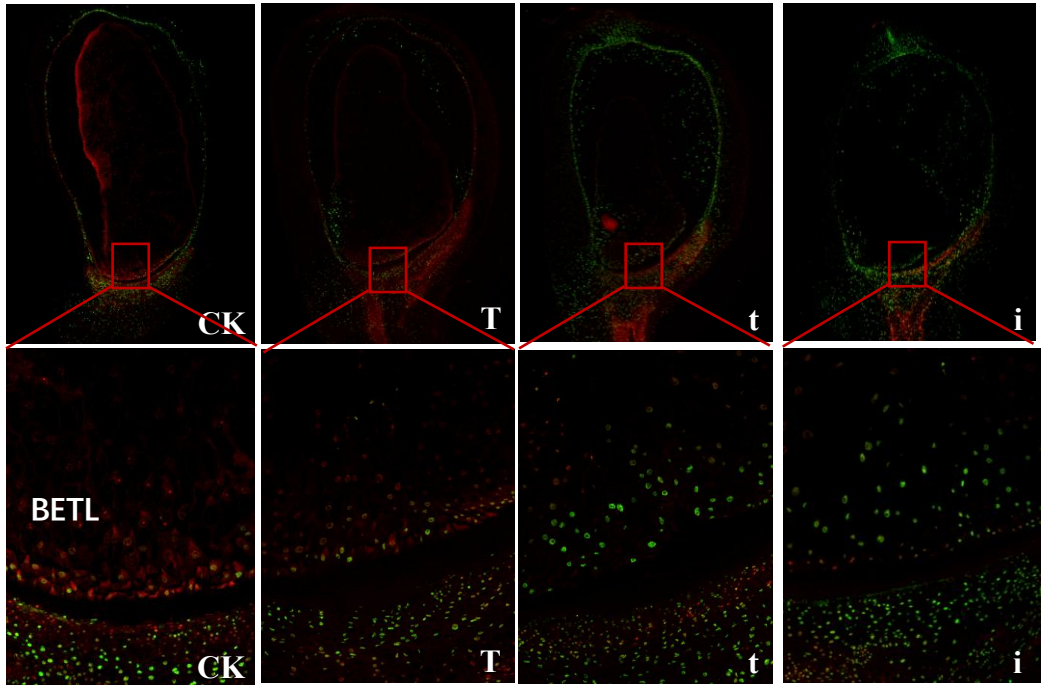


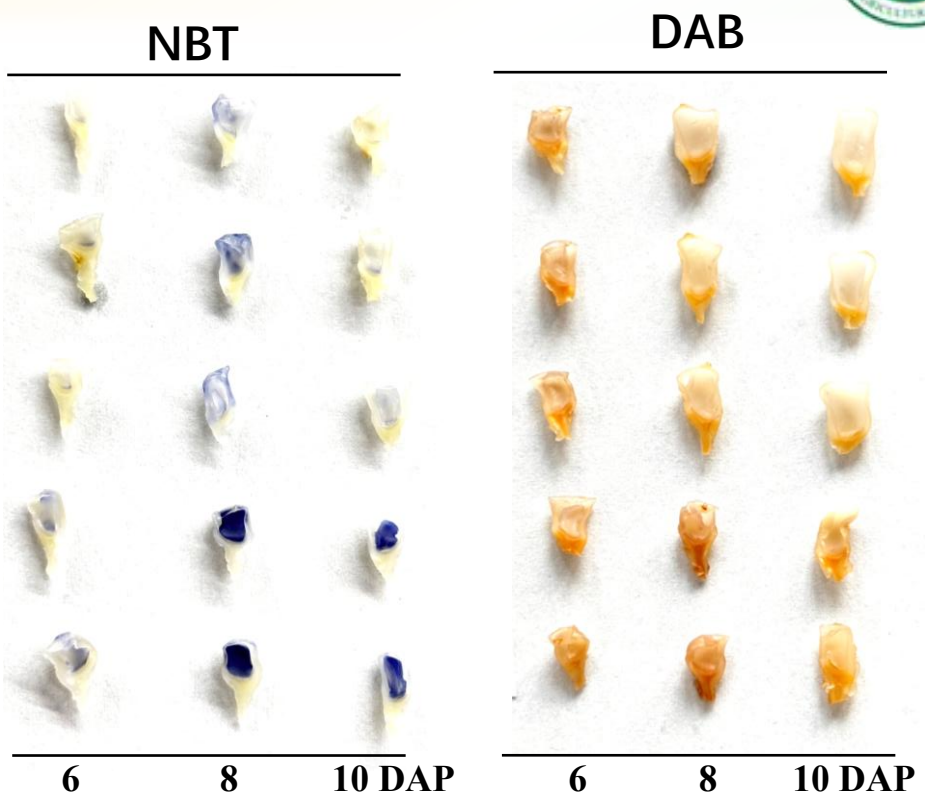


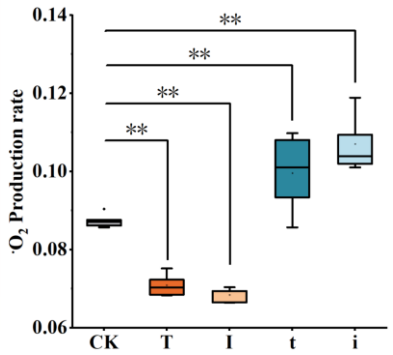


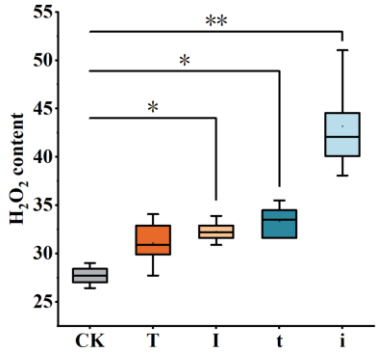
Result 2 Heat stress induces ROS accumulation and promotes kernel death

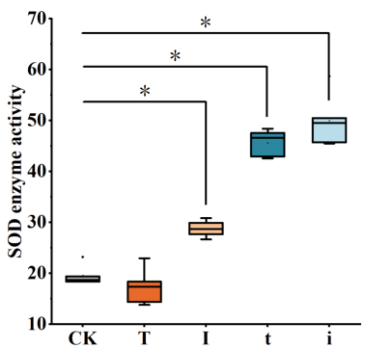


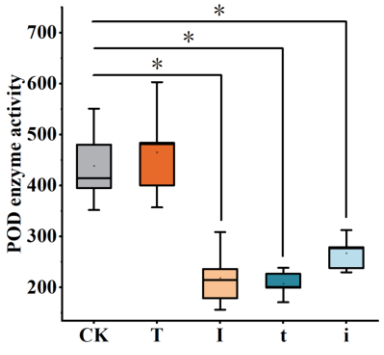


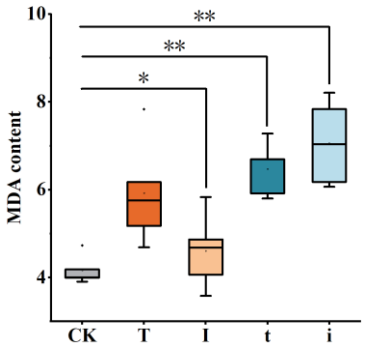








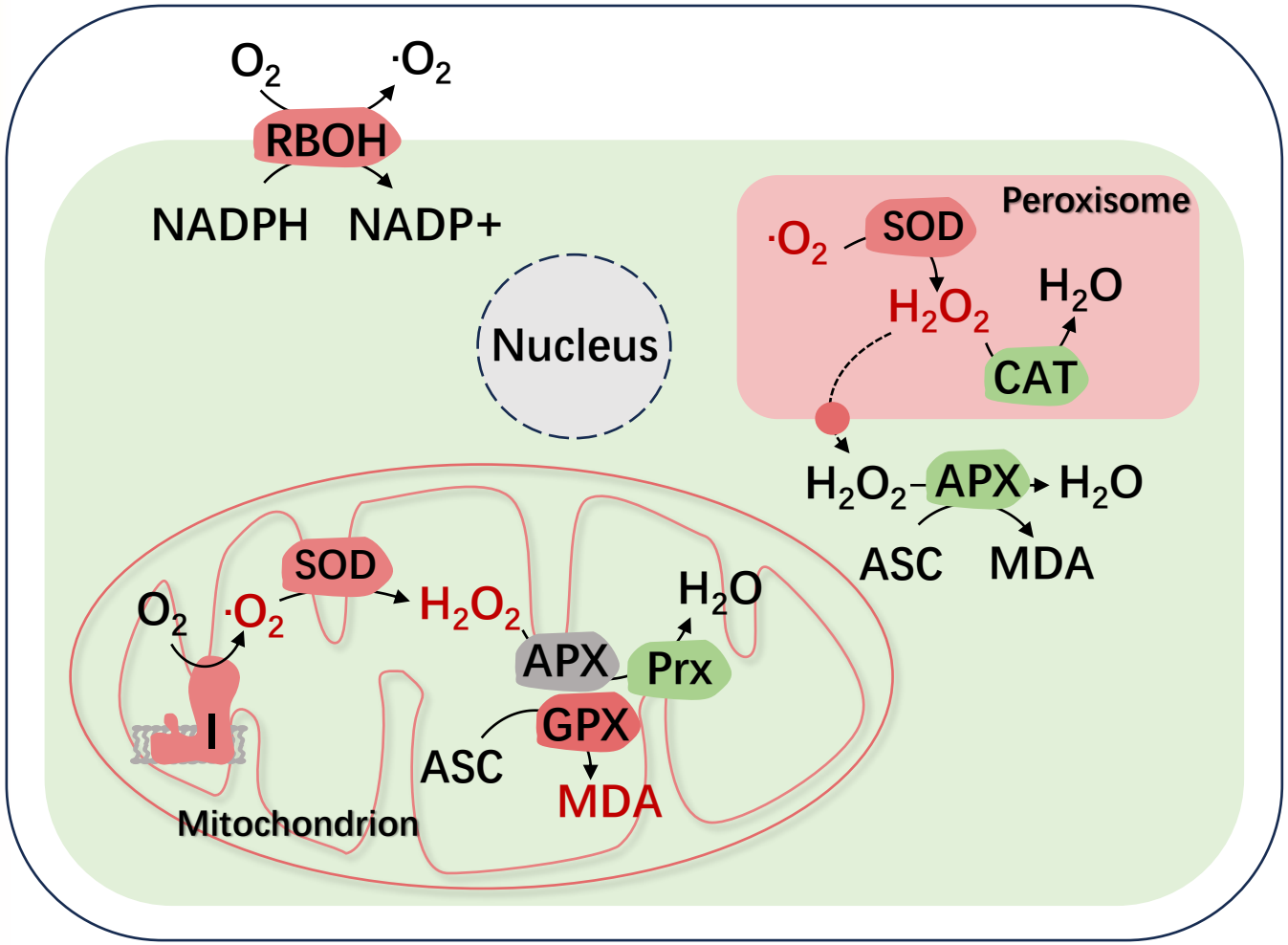




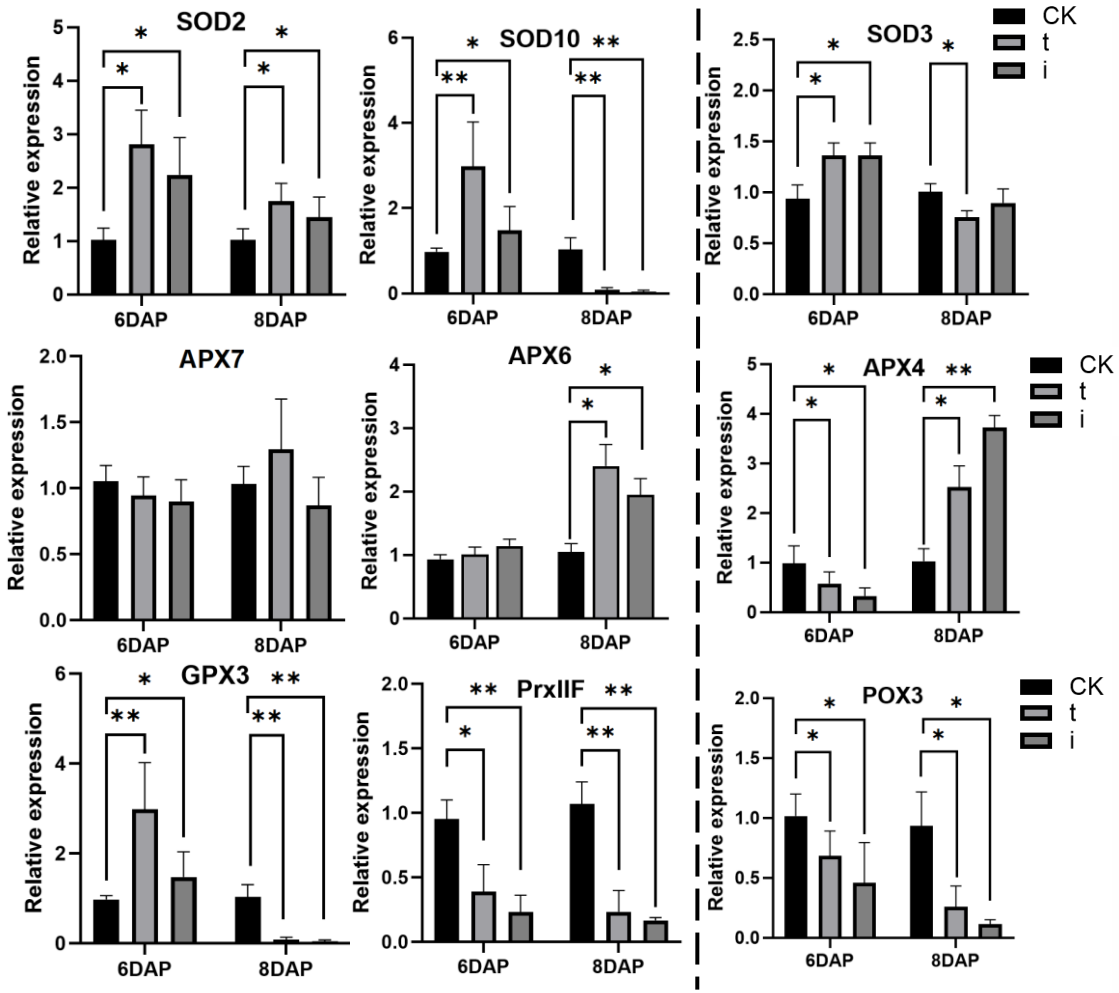
Programmed cell death occurred in the BETL at 6DAP

ROS accumulated excessively in the BETL at 6DAP

Result 3 Heat stress disrupts the ROS scavenging system localized mitochondria

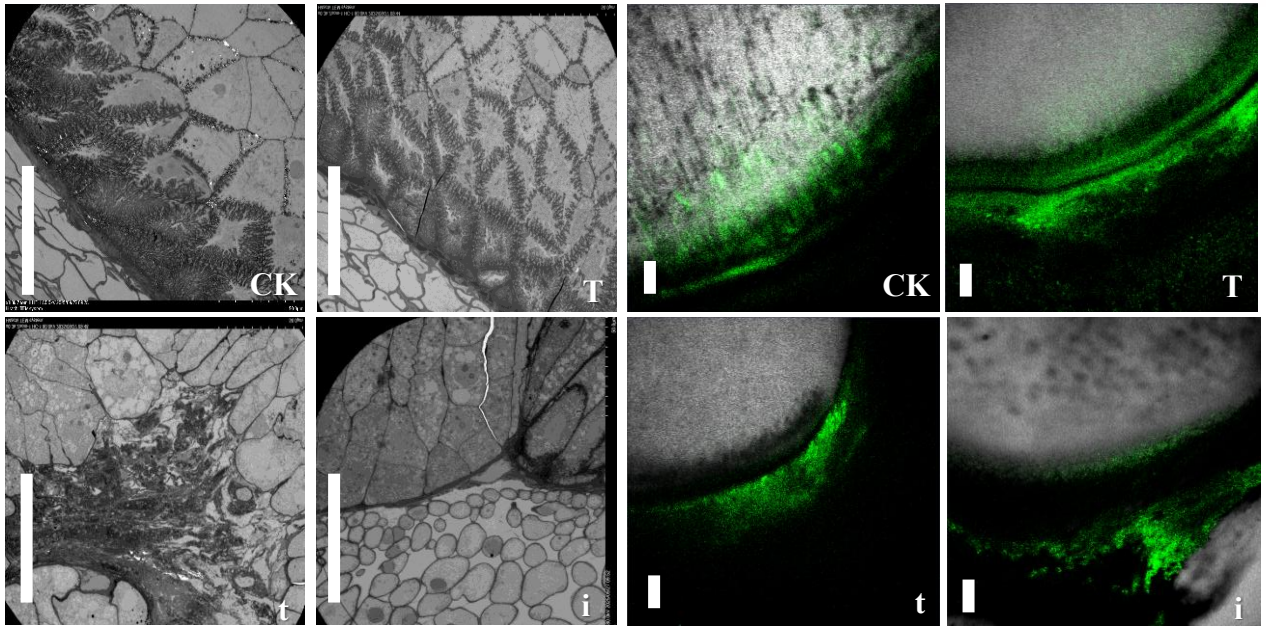


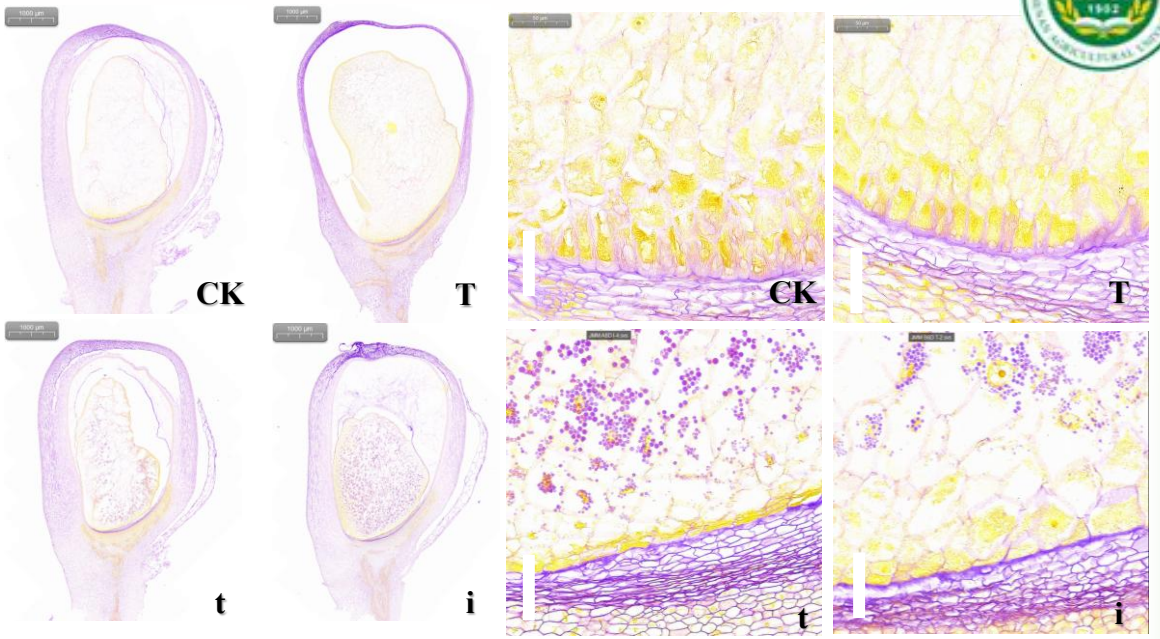
Mitochondria-localized ROS-scavenging

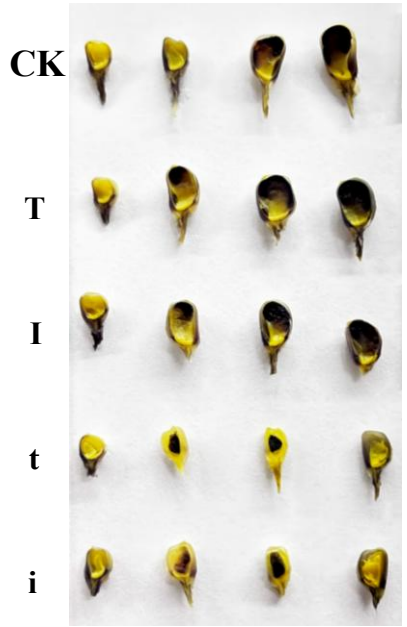


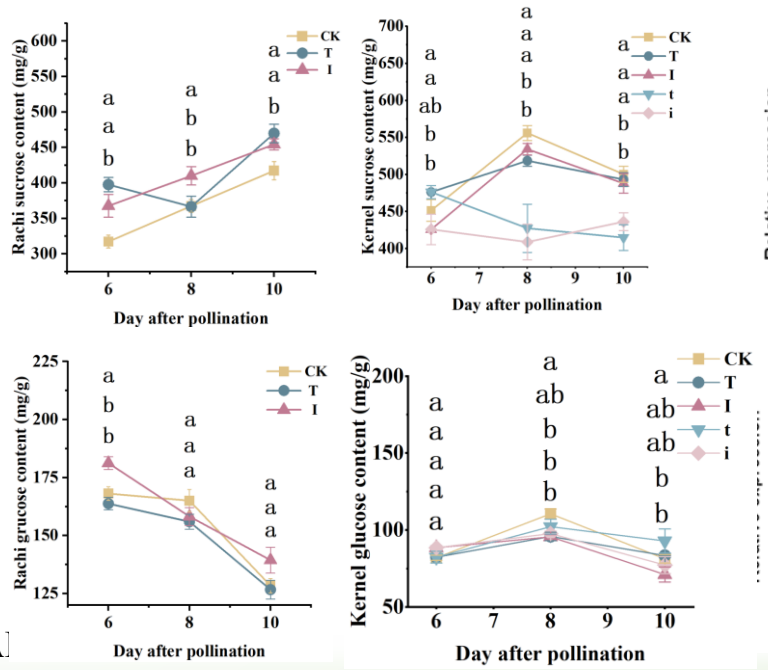
Mitochondrial SOD gene expression were significantly increased
Prx expression was significantly decreased under heat stress at 6DAP

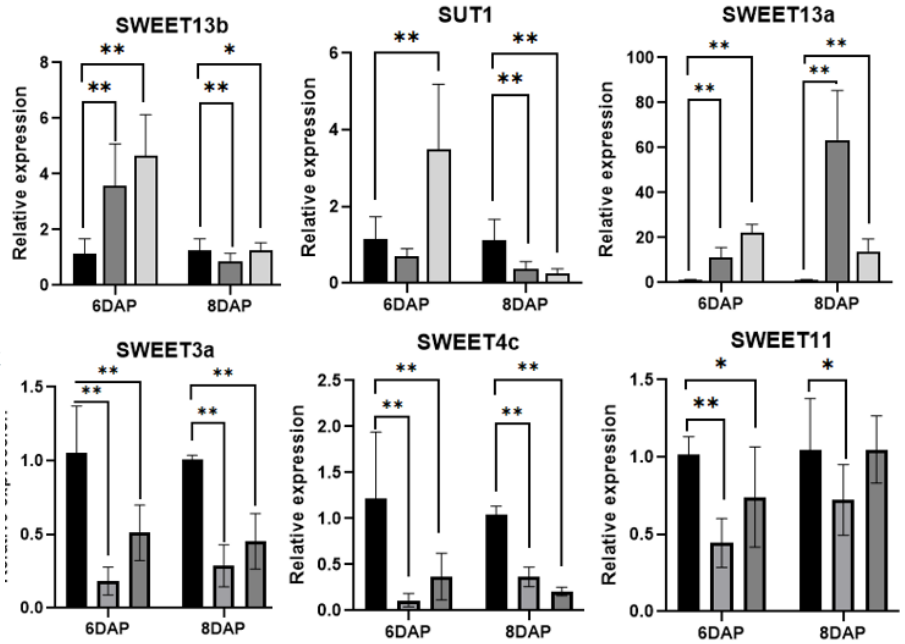
Result 4 Heat stress disrupts the development of BETL and prevents sugar transport





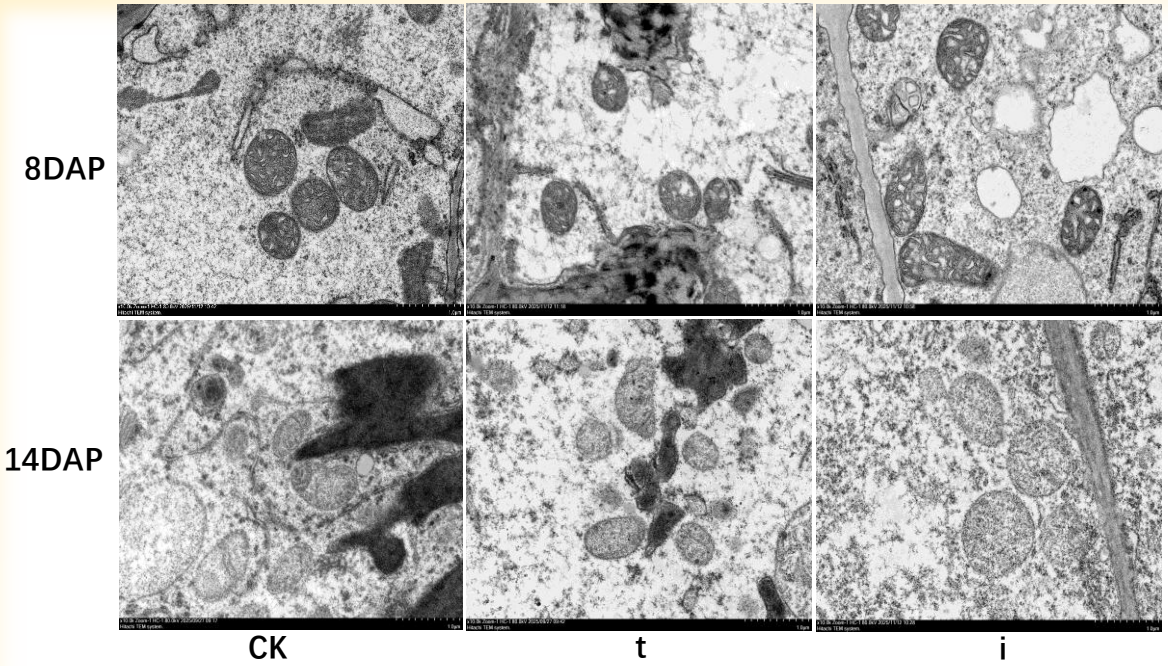


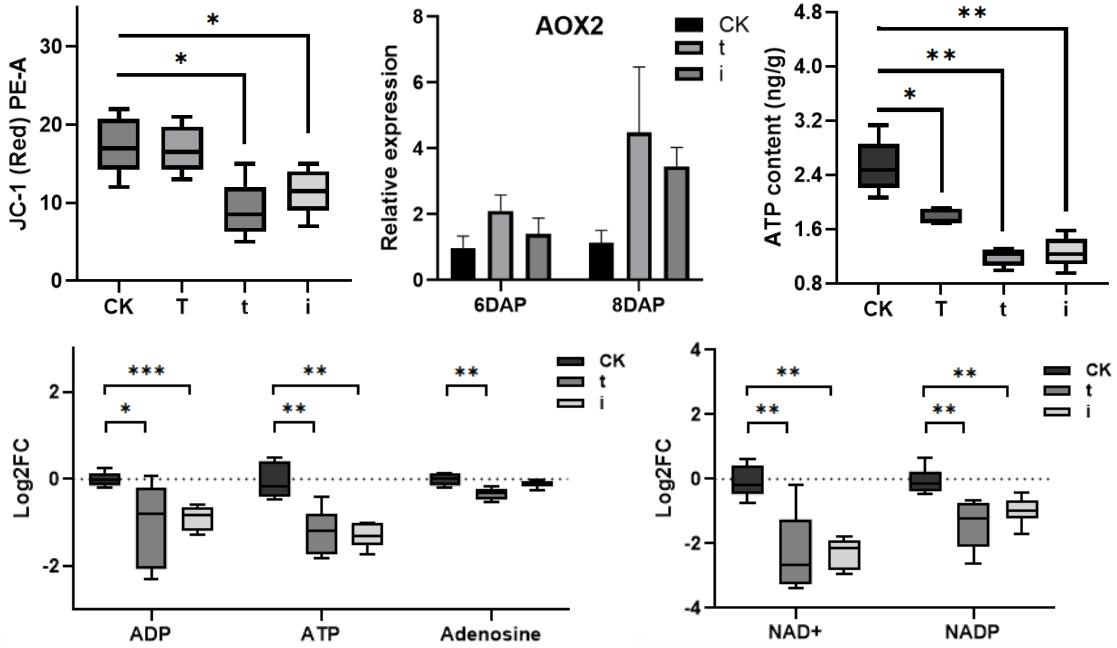


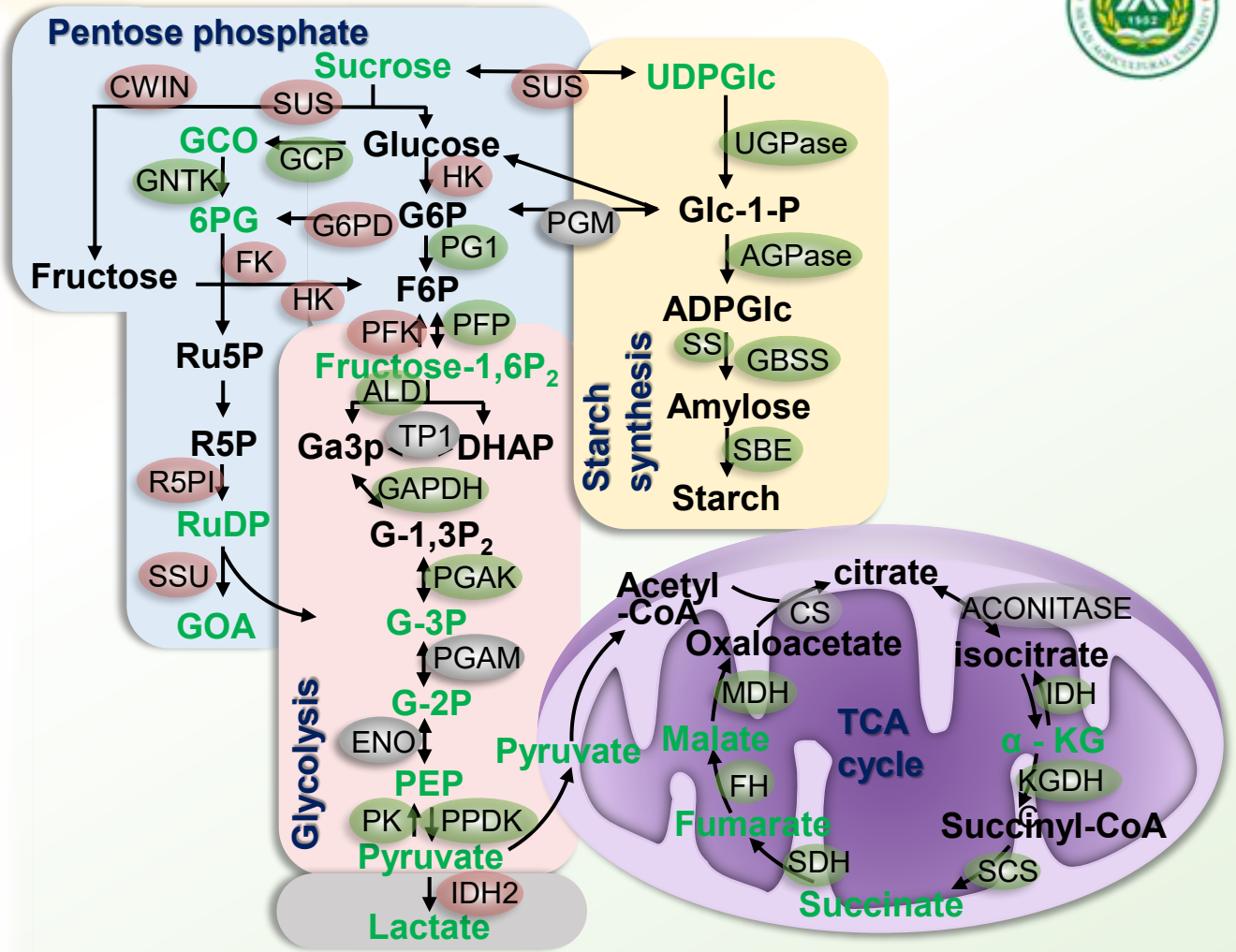


BETL development was impaired, leading to a sharp decrease in sugar transport activity

Result 5 Heat stress disturbs mitochondrial function and promotes mitophagy



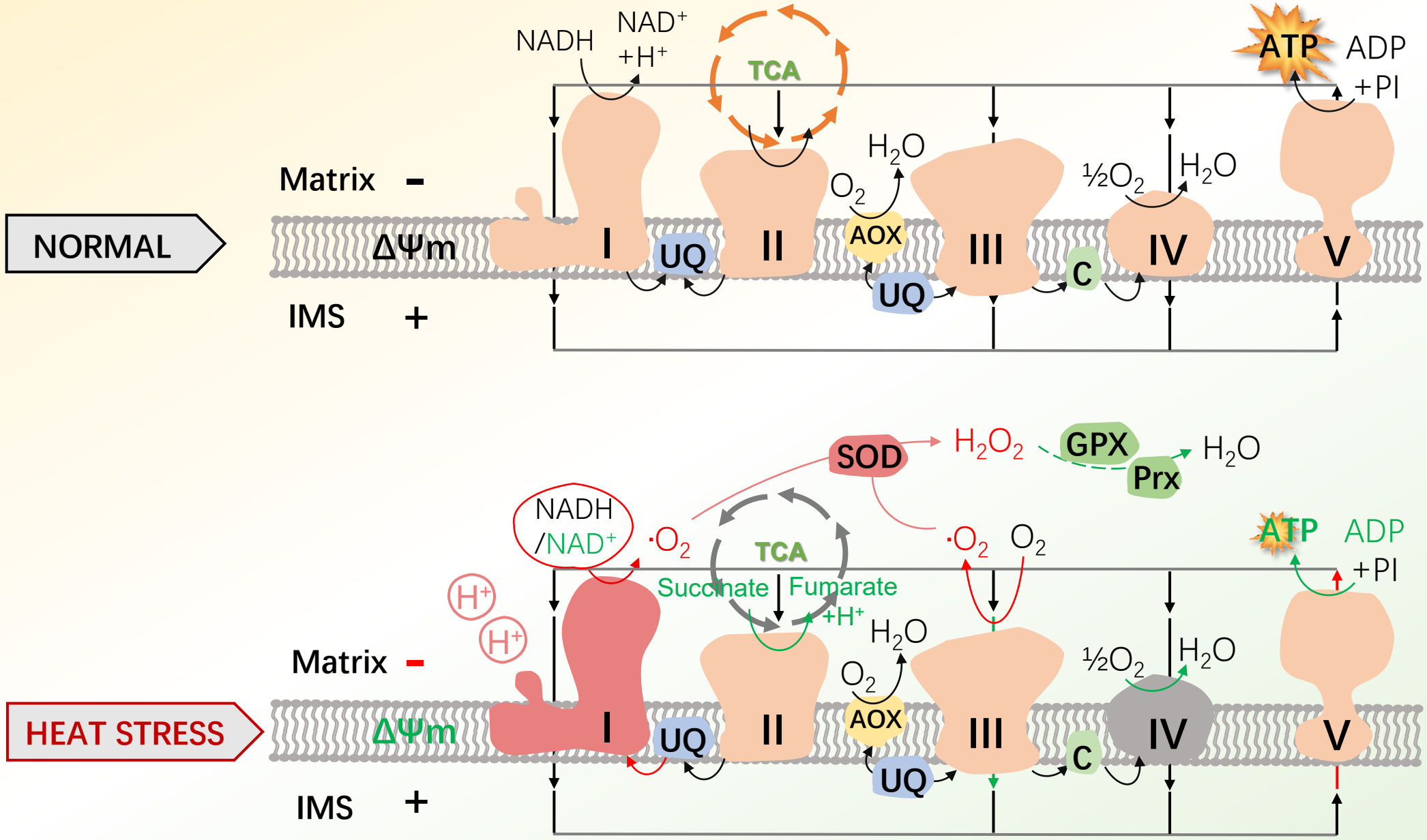


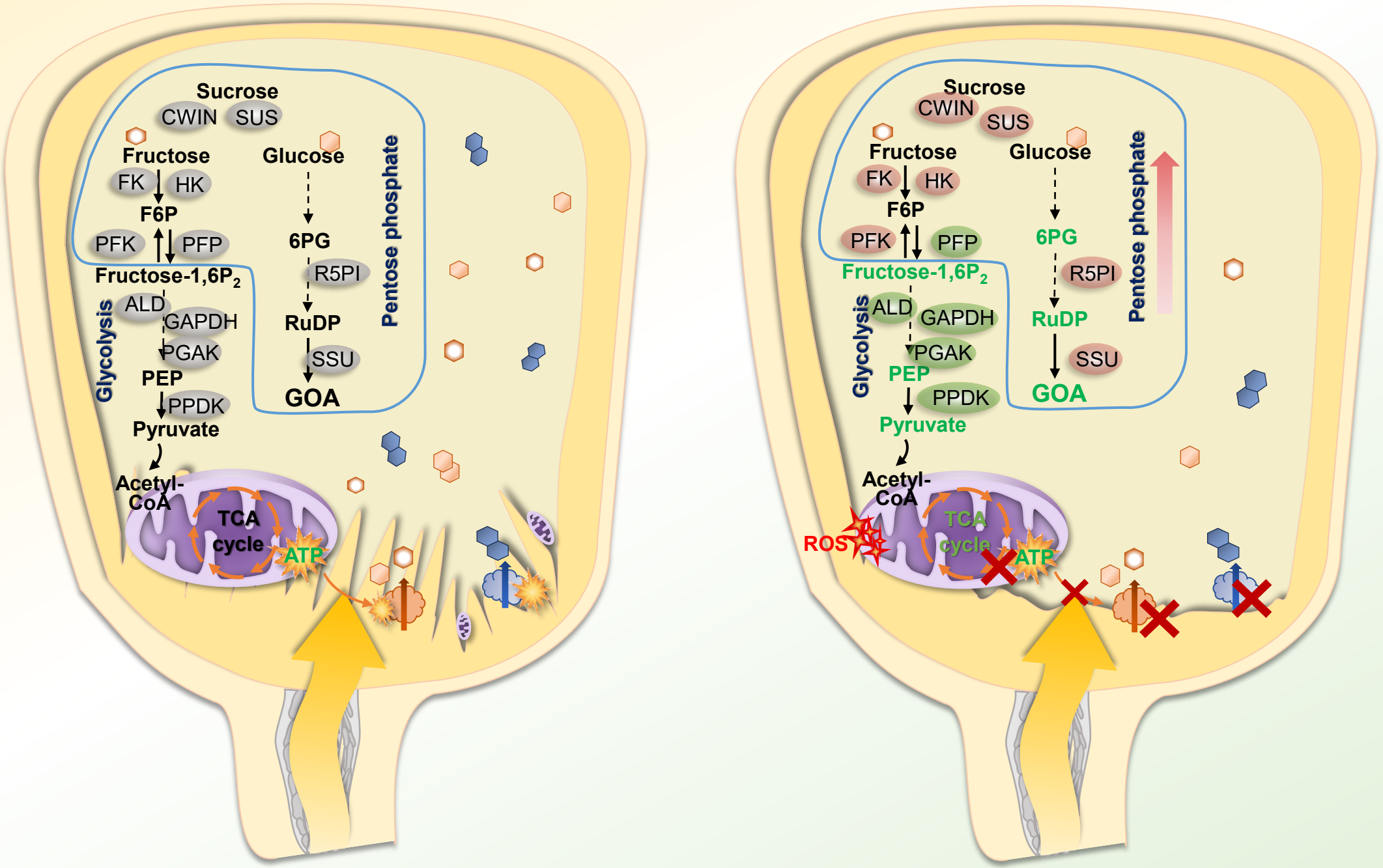


Premature mitochondrial stress and apoptosis occurred, leading to insufficient ATP production

The activities of key enzymes in the pentose phosphate pathway (PPP) showed a compensatory increase, but the production of NAD^+ was blocked.

Result 5 Heat stress interfered with the mitochondrial ROS scavenging system




NORMAL
Sucrose
CWIN
SUS
Fructose
Glucose
FK
HK
F6P
PFK
PFP
6PG
R5PI
Fructose-1,6P2
Glycolysis
ALD
GAPDH
RuDP
Pentose phosphate
PGAK
SSU
PEP
GOA
PPDK
Pyruvate
Acetyl-CoA
TCA cycle
ATP
HEAT STRESS
Sucrose
CWIN
SUS
Fructose
Glucose
FK
HK
F6P
PFK
PFP
6PG
R5PI
Fructose-1,6P2
Glycolysis
ALD
GAPDH
RuDP
Pentose phosphate
PGAK
SSU
PEP
GOA
PPDK
Pyruvate
Acetyl-CoA
ROS
TCA cycle
ATP