Experiment setup and crop model calibration for assessing the impacts of haze on crop growth and yield

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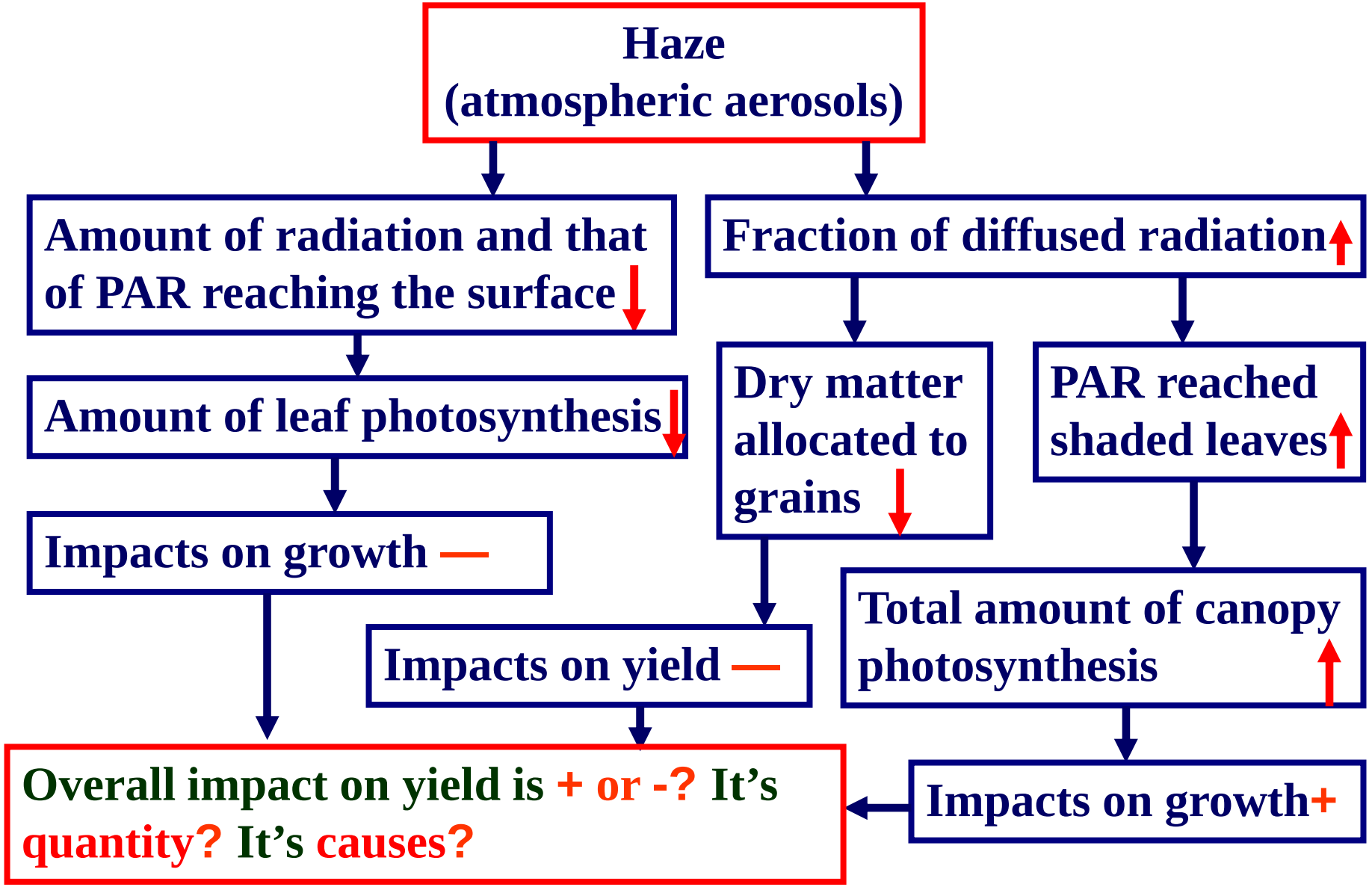
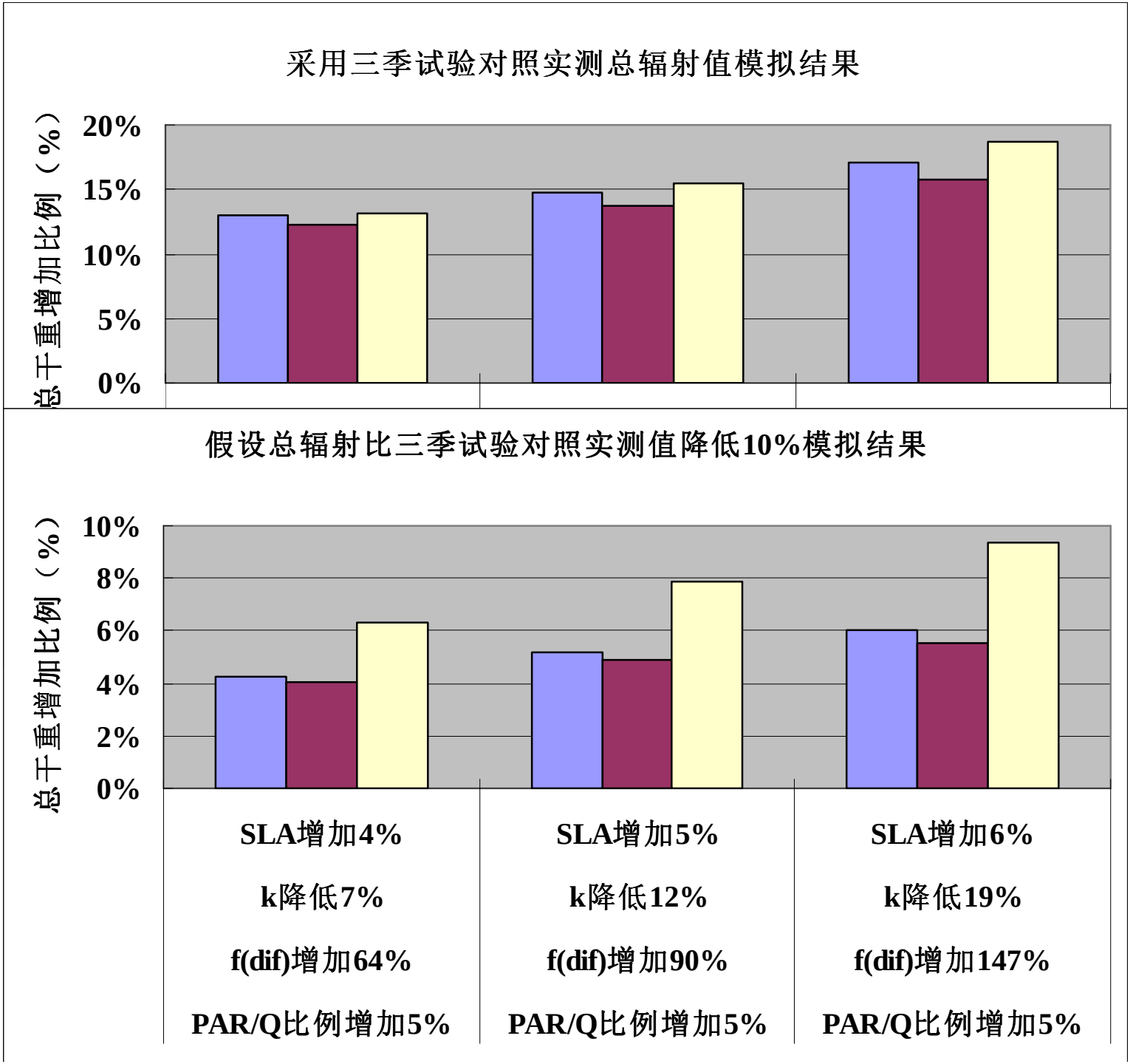
Outline

- Impacts of haze on crop growth
- Model applications
- Experiment setup

Impacts of haze on crop growth

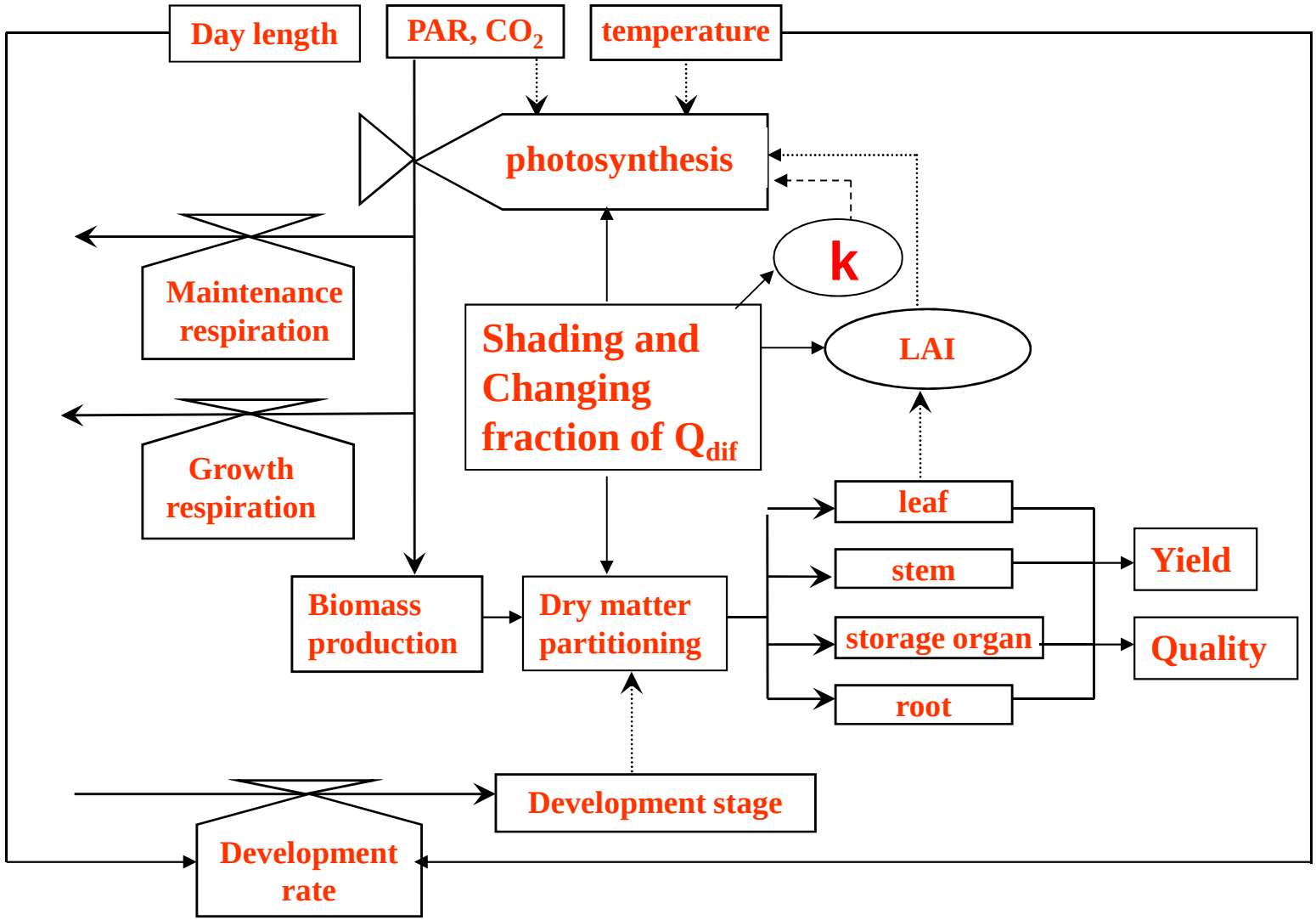


Simulation results for wheat crop biomass production in Nanjing



Model calibrations

Structure of Crop Simulation Model

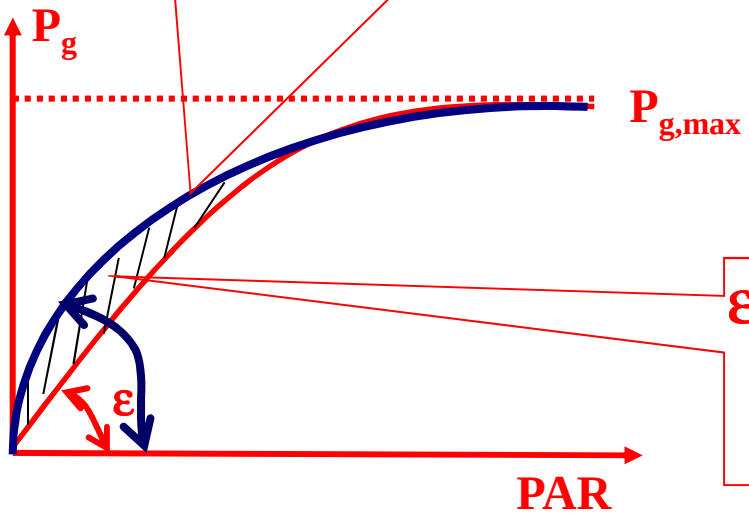


Leaf Photosynthesis

Leaf photosynthesis rate P_g [kg CO_2 ha^{-1} h^{-1}]:

$$P_g = P_{g,max} * [1-exp(-\varepsilon * PAR / P_{g,max})]$$

Under shading (more diffused radiation, ε will increase due to more chlorophylls in leaves



ε increase can compensate some reduction of P_g caused by reduced PAR

Canopy Photosynthesis

Canopy photosynthesis rate P_c : Integrate P_g *over 0~LAI*:

$$P_c = \int P_g d(LAI) = \int [P_{g,max}(1-exp\,(-\varepsilon * PAR_L / P_{g,max})]d(LAI)$$

$$PAR_L = PAR_o * exp(-k * LAI_L)$$

PAR_o : the PAR above the canopy

PAR_L : the PAR at depth L (where LAI, accumulated from top to depth L, is LAI_L) inside the canopy

***k*: the canopy light extinction coefficient**

Smaller for diffused radiation Q_{dif}
Larger for direct radiation Q_{dir}

more Q_{dif} reaches lower leaves increase canopy RUE

Leaf area index

Leaf area index growth rate:

$\Delta LAI/\Delta t = (\Delta WLV/\Delta t)*SLA$

SLA: specific leaf area (m^2/kg WLV).

SLA increases under shading (more diffused radiation) conditions.

Promote the fast establishment of the canopy, hence increase canopy RUE

Yield

Yield= biomass*HI

HI: harvest index

HI deceases under shanding conditions.

Negative impact on yield

Model parameters need to be calibrated

ε: initial light use efficiency of leaves

***k*: canopy light extinction coefficient**

SLA: specific leaf area

Fraction of dry matter allocated to different organs (leaves, stems and grains)

HI: harvest index

Experiment setup

Experiment design:

Crop variety: use represent cultivar that has the largest sowing area in the exp region.

Treatment: using PE plastic film as shading material to simulate the haze conditions.

Films installed at a height of 2 m above ground on steel tube frames.

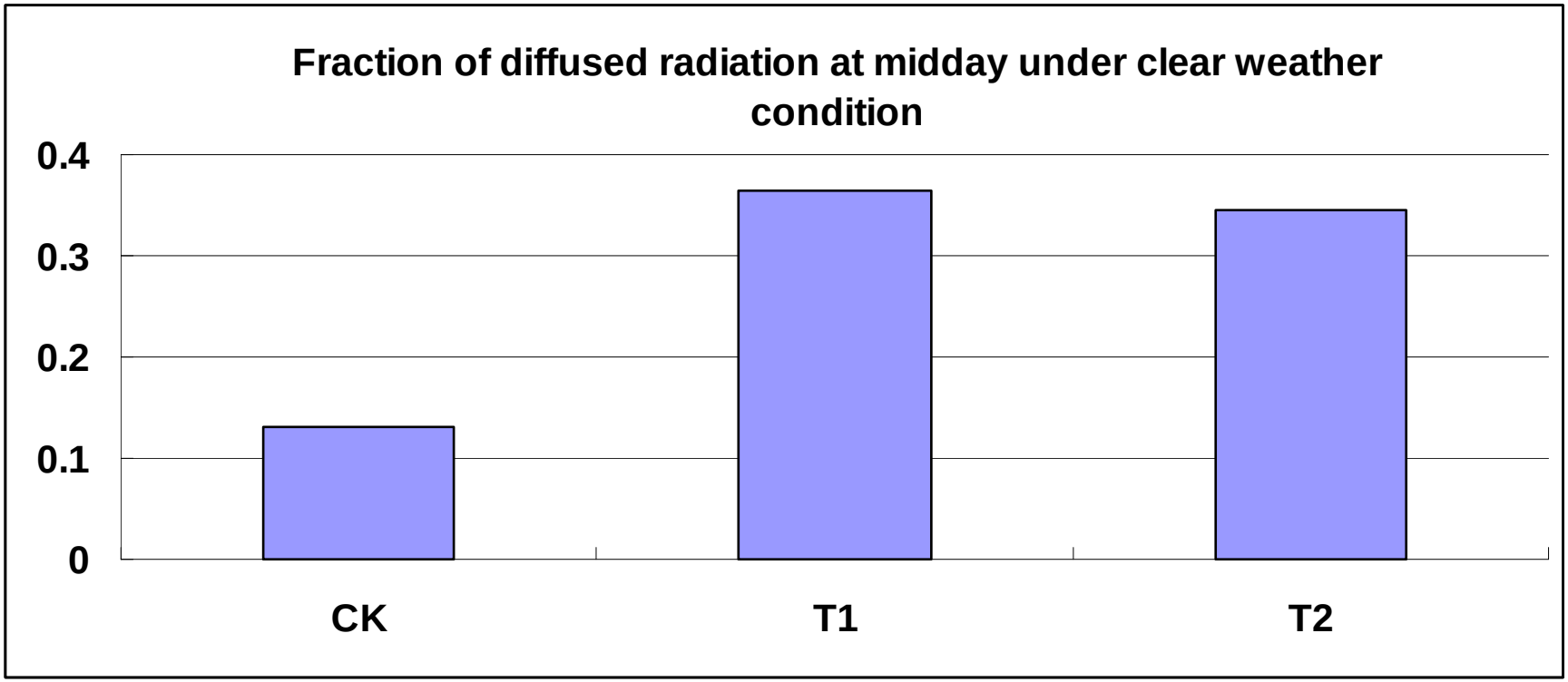
The films are open in the morning after sunrise and closed in the afternoon near sunset every day except rain and overcast days, and should be closed when it is going to have rain during a day.

Treatment:

Level of shading——20~25% reduction of global radiation using PE plastic film (3 layers) with global radiation transmittance of 0.93.

Under the films, the fraction of diffused radiation is about 2.6~2.8 times of CK at midday under clear weather conditions.

Plot area —— 4 (south-north) × 5 (east-west) = 20 m^2, 3 replicas for CK and each treatment. All plots are arranged with randomized block.


Fraction of diffused radiation at midday under clear weather condition
0.4
0.3
0.2
0.1
0
CK
T1
T2

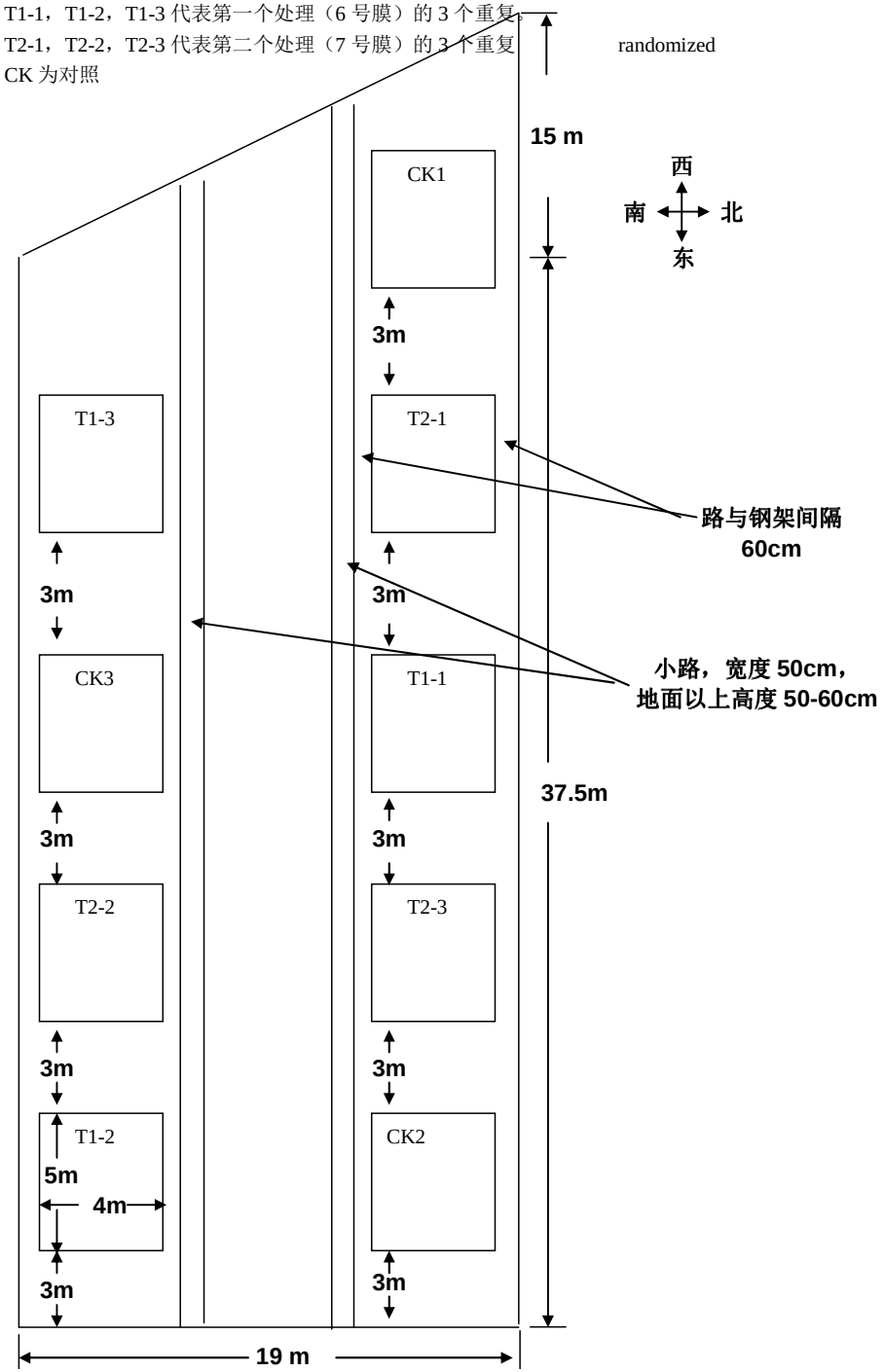
江苏农科院试验整块地面积为 19*37.5+15*19/2=855 m^2

T1-1，T1-2，T1-3 代表第一个处理（6 号膜）的 3 个重复，

T2-1，T2-2，T2-3 代表第二个处理（7 号膜）的 3 个重复

CK 为对照

randomized



Measurements

1. Soil N, P, K (inorganic or available and total) contents before planting
2. Global and diffused radiation, PAR, net radiation*, air temperature at 1.5m above ground; canopy temperature* (after canopy closed)
3. Development stage observation (sowing or transplanting, tillering, jointing, booting, heading, milk filling, ripening, and harvest date)

Measurements

4. Non distractive measurements

(1) At each development stage: number of stems (tillers) per unit area; k, plant height, number of leaves per main stem, number of tillers per plant.

(2) After heading: number of spike per unit area.

(3) At each development stage after treatment started: photosynthesis——PAR response curves (LI-6400) and chlorophyll (SPAD-502) of fully open green leaves at top, middle and lower level of the canopy.

Measurements

5. Distractive measurements

(1) At each development stage: sample 3 hills (for rice) or 10 plants for wheat per plot to measure total biomass, organ dry weight, LAI (LAI-2000), SLA, N content of organs.

(2) At harvest: number of spike per plant, number of spikelet per spike, number of non fertilized spikelet per spike, number of grains per spike, grain weight (1000 grains), total biomass, harvest index, and yield.

Questions?