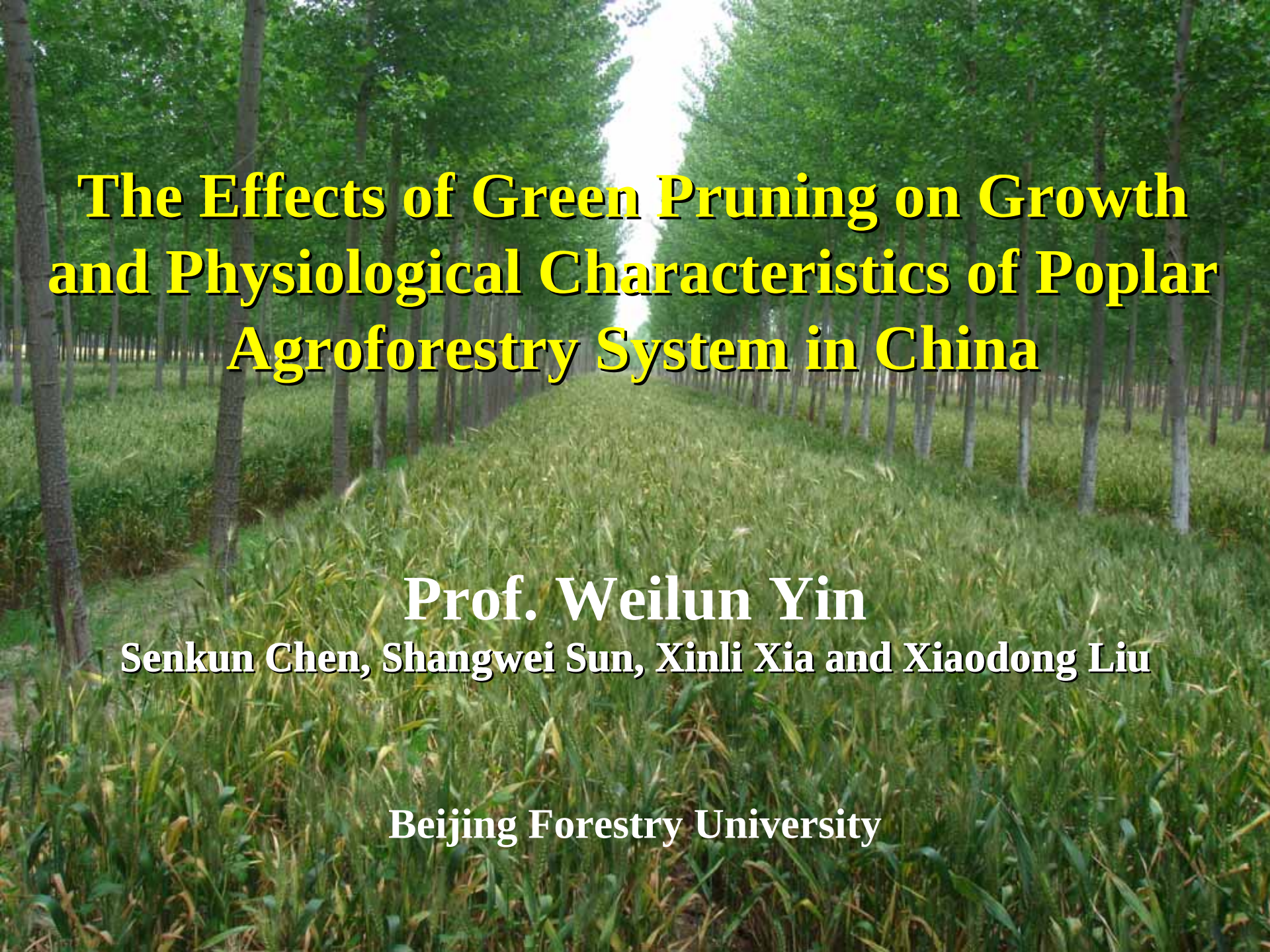


The Effects of Green Pruning on Growth and Physiological Characteristics of Poplar Agroforestry System in China

Prof. Weilun Yin

Senkun Chen, Shangwei Sun, Xinli Xia and Xiaodong Liu

Beijing Forestry University

Outline

- Introduction
- Materials and Method
- Results
- Conclusion
- Future research work

Introduction

- There totally have about $7\times10^6 hm^2$ poplar plantation in China.
- Poplar is an important high yield plantation species in China.
- In the high spacing poplar plantation, the intercrop measure were used in many provinces in China.
- The research on the growth and physiological response to pruning in poplar agroforestry systems is very important in China.

Introduction

- In many agroforestry systems, trees and crops compete inevitably for light, nutrients and other resources.
- Pruning of the tree component is a powerful approach to regulate this competition.
- So pruning is a common practice in a many traditional and modern agroforestry systems

Introduction

Wheat in agroforestry system

Monoculture wheat

Pruning can increase the light transmitting in agroforestry system and increase the crop production.

Introduction

Pruning can improve the wood quality. (no nodular wood)

Pruning can improve the tree stem shape.

Introduction

The objectives of this research:

(1) How the trees and crops response to different pruning intensity?

(2) How to build a optimal pruning mode ?

The optimal pruning intensity should involve a tradeoff between maximising gains both in crop production and wood quality , and minimising impacts on tree growth.

Materials and Method

- **The studied poplar agroforestry system consist of *Populus euramericana* cv. '74/76' (3-year-old), Winter wheat and Summer maize.**
- **There are three research sites located in Shandong and Hebei province in China.**
- **Total five pruning treatments, unpruned (CK), 1/6, 2/6, 3/6, 4/6crown length was pruned, each treatment had 40 trees.**
- **The pruning were conducted in 2006, and the grow and physiological response were measured during and after the growing season after pruning.**

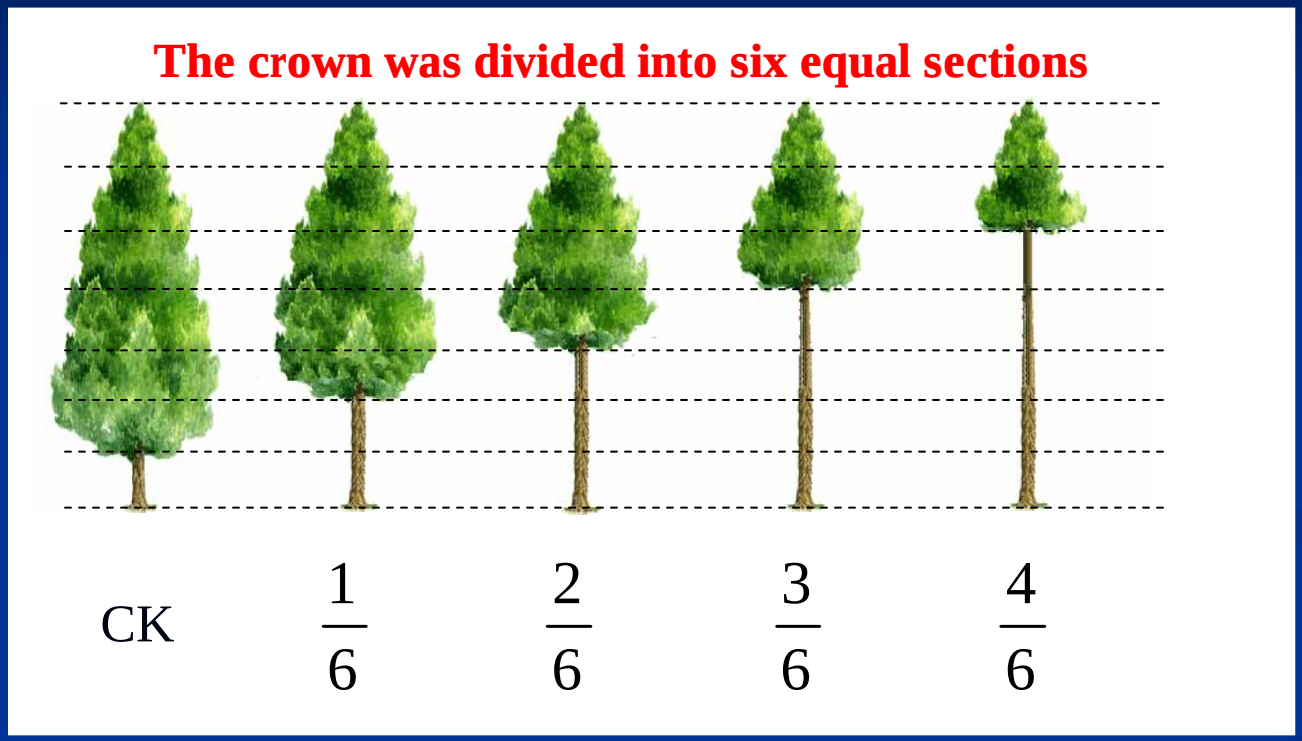
Experiment Materials

Populus euramericana cv. '74/76'

Winter wheat

Summer maize

Sketch map of pruning treatment



Total five pruning treatment: unpruned(CK), 1/6(17%), 2/6(33%), 3/6(50%), 4/6(67%) crown length was pruned, each treatment had 40 trees。

Results

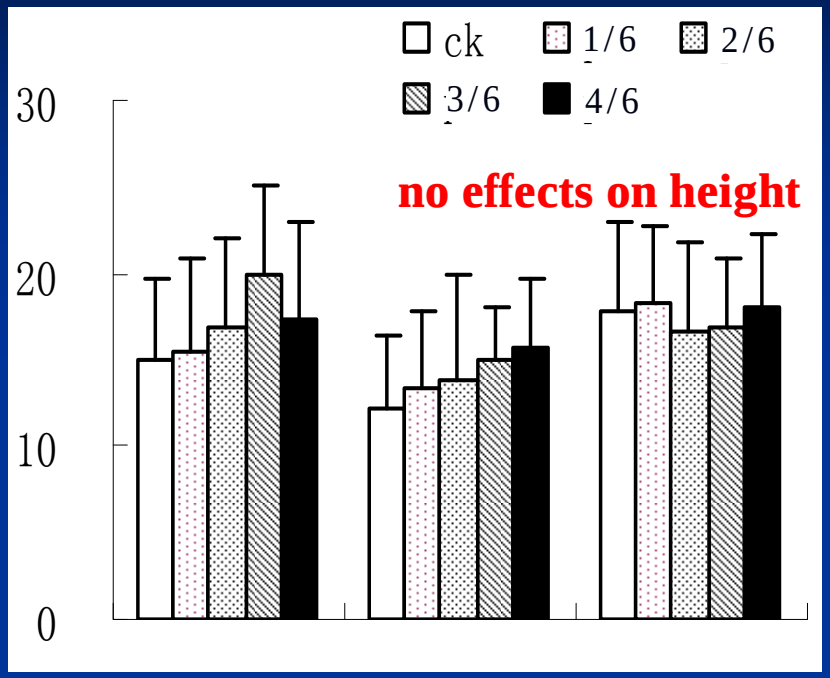
- Tree growth responses to pruning
- Effects of pruning on tree leaf net photosynthetic rate and transpiration rate
- Effects of pruning on sap flow and stomatal conductance.
- Effects of pruning on the microclimate under the canopy
- The crop response to pruning

Tree height response to the pruning

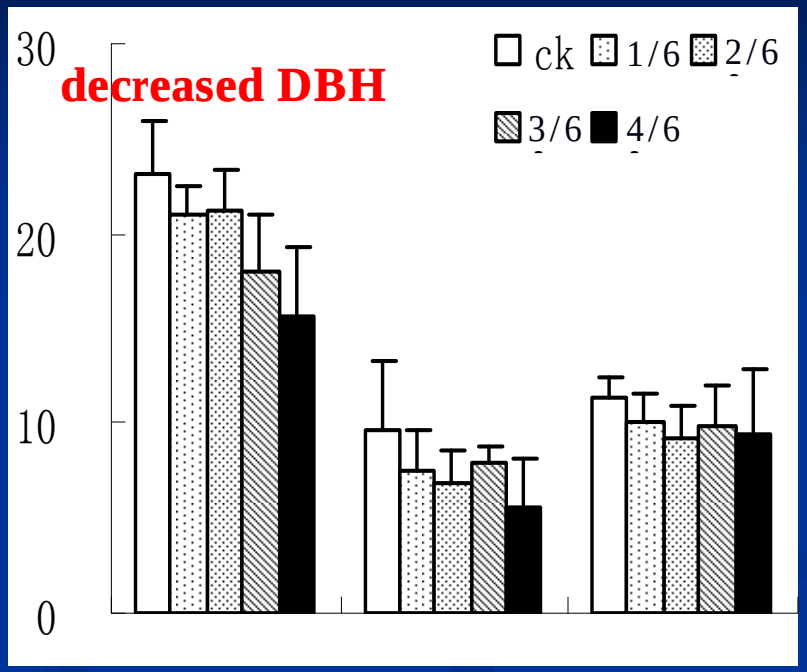
Treatment	Total Height (m)		
	Before pruning	**After one growing season**	**After two growing season**
CK	9.971±0.450	11.624±0.517	14.497±0.683
1/6	10.063±0.449	11.748±0.529	14.630±0.614
2/6	10.156±0.582	12.031±0.736	14.659±0.898
3/6	9.933±0.476	12.136±0.576	14.987±0.655
4/6	9.851±0.467	11.723±0.444	14.518±0.555

The effects of pruning on the tree height increment was not significant ($P<0.05$)

The total height and DBH(diameter of bosom height) response to pruning



Dezhou 2m×6m | Dezhou 3m×4m | Henshui 2m×6m

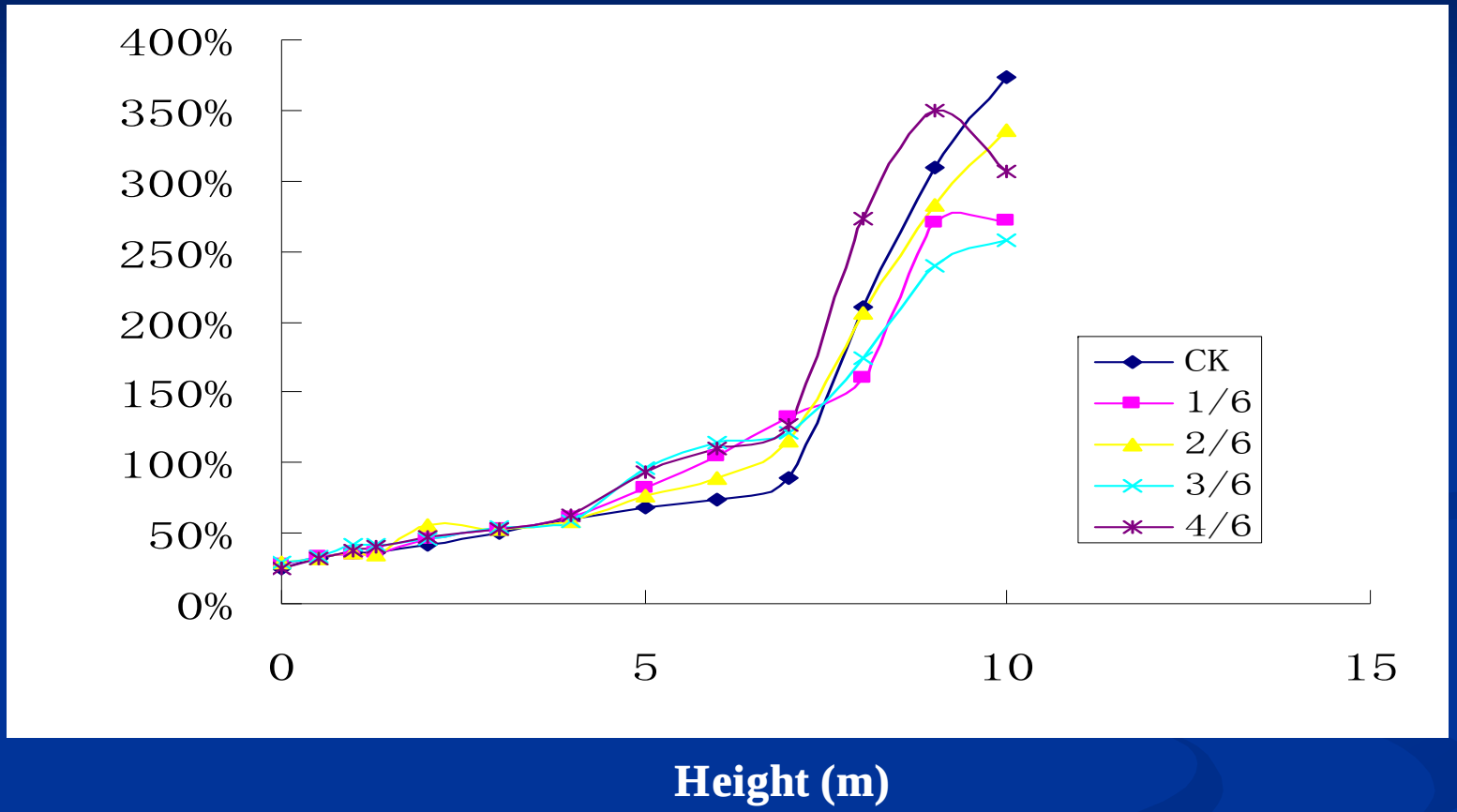


Dezhou 2m×6m | Dezhou 3m×4m | Henshui 2m×6m

The pruning had no effects on height increment, but significantly decreased DBH increment.

Pruning can improve the tree stem shape

The diameter at different height response to pruning



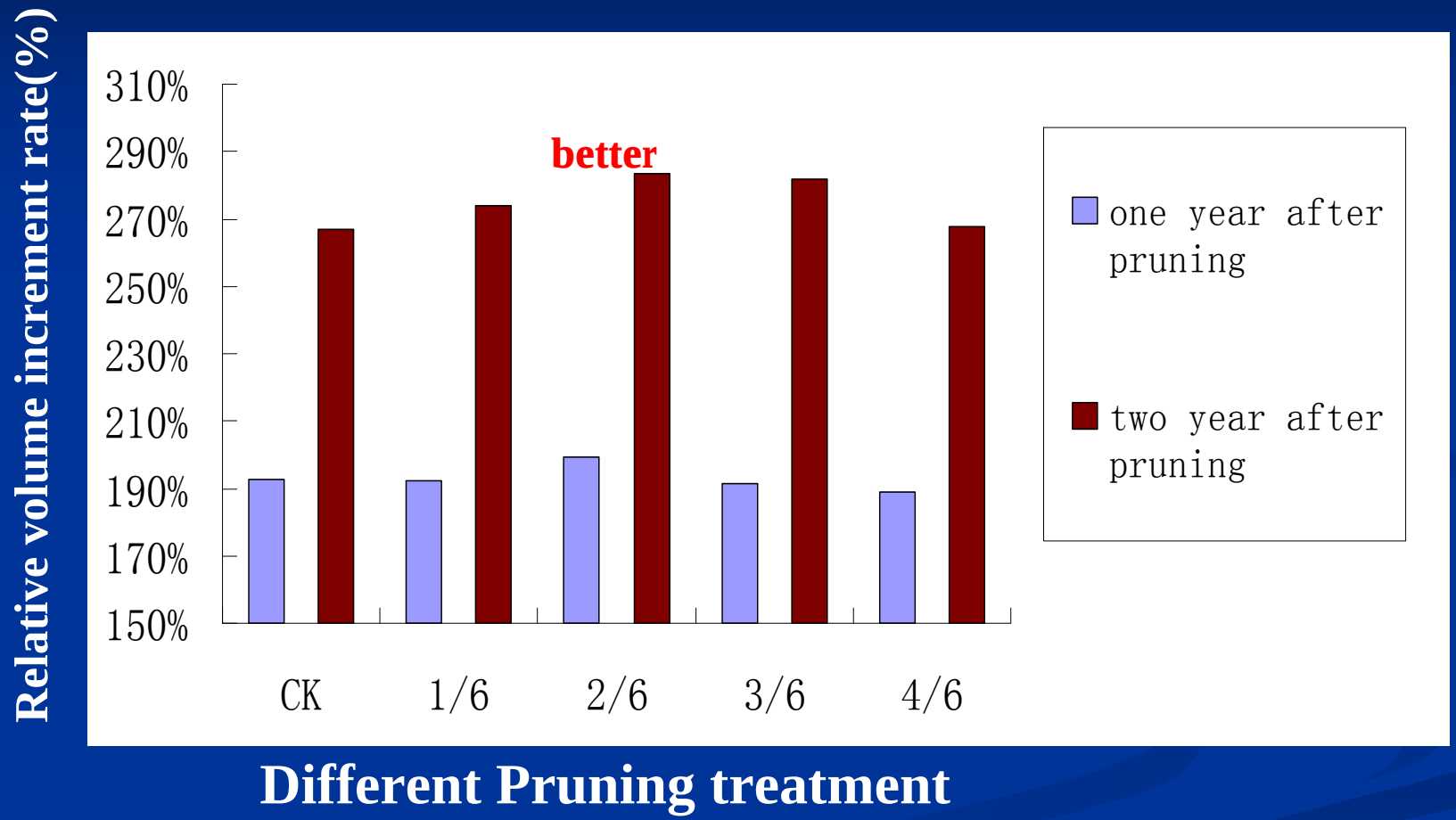
Pruning increased the diameter growth in the top crown section, therefore decreased the tree taper and increased the volume .

Effects of pruning on tree volume

	Pruning intensity				
	CK	1/6	2/6	3/6	4/6
Total volume before pruning($m^3 \cdot hm^{-2}$)	27.225	26.558	24.951	26.410	23.581
Volume increment one year later ($m^3 \cdot hm^{-2}$)	25.189	24.521	24.744	24.147	20.995
Volume increment on the second years ($m^3 \cdot hm^{-2}$)	20.292	20.014	24.274	21.881	18.671
Total volume increment two years later ($m^3 \cdot hm^{-2}$)	45.481	44.535	49.018	46.028	39.666
Relative volume increment rate one year later (%)	63.26	63.17	66.30	62.75	61.61
Relative volume increment rate on the second year (%)	32.44	32.76	39.26	35.58	34.63
Relative volume increment rate two year later (%)	182.05	182.43	198.21	186.26	182.73

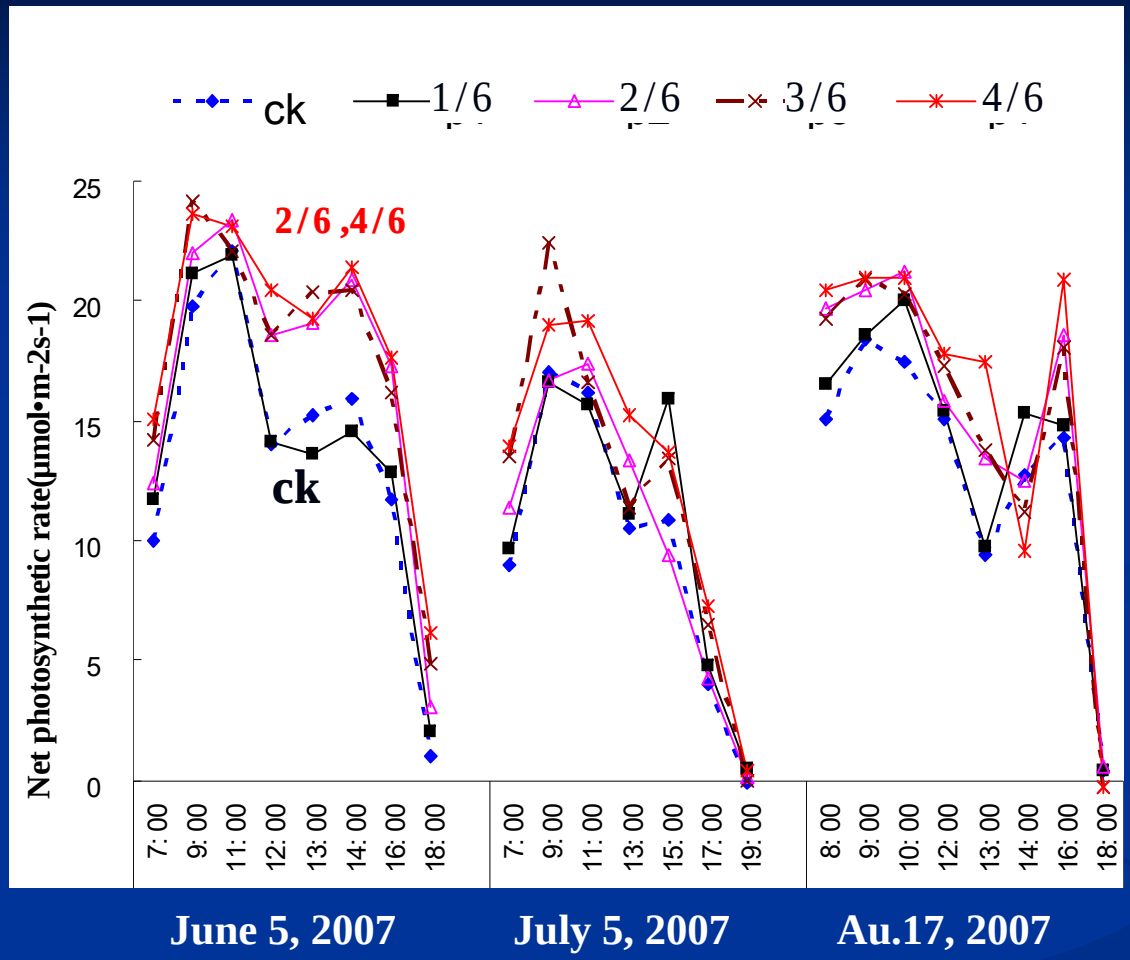
the 2/6 treatment had the highest relative volume increment

Effects of pruning on tree volume



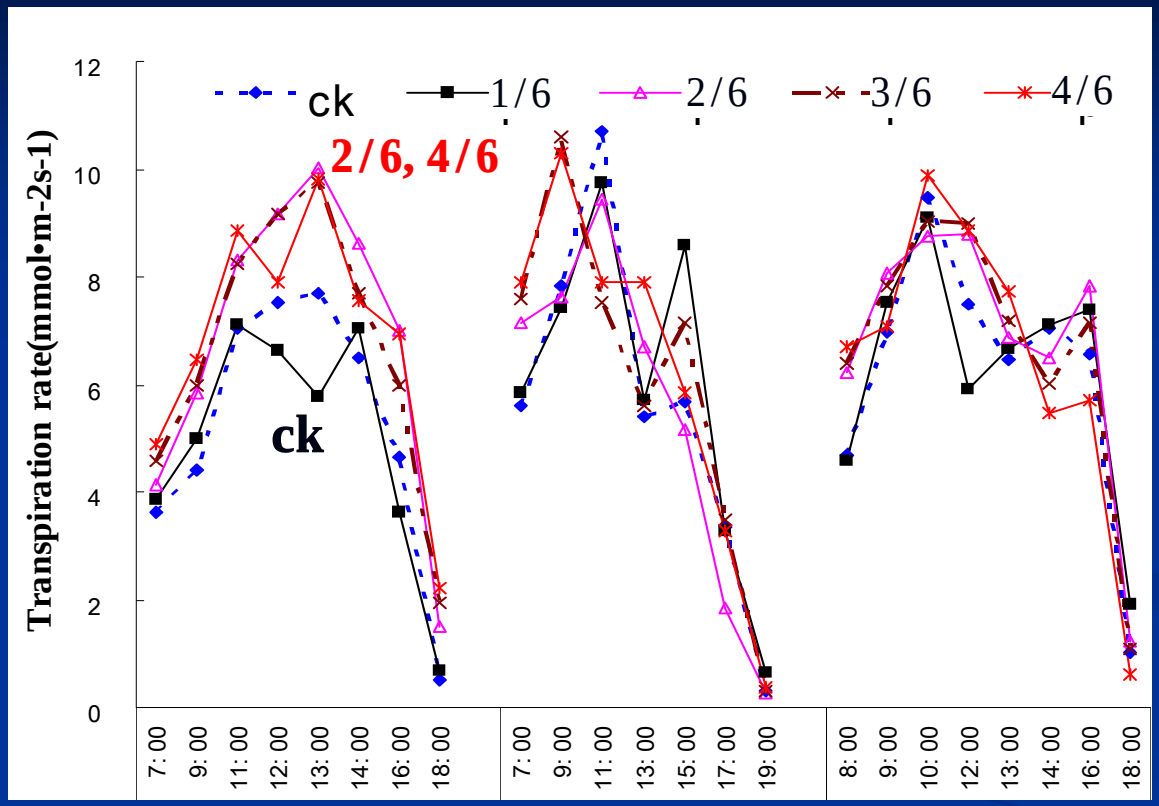
the 2/6 treatment had the highest relative volume increment

Effects of pruning on tree net photosynthetic rate



Daily change of leaf net photosynthetic rate at top crown under different pruning treatment

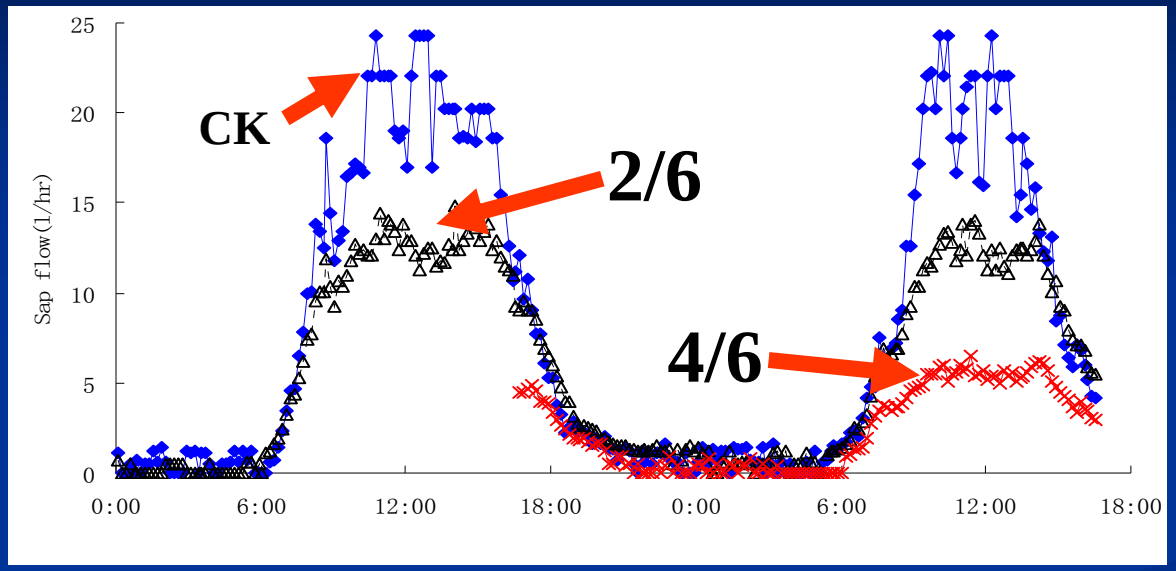
Effects of pruning on tree transpiration rate



The daily change of leaf transpiration rate at top crown under different pruning treatment

Pruning can effectively increased the leaf net photosynthetic rate and transpiration rate at top crown, especially under the drought condition.

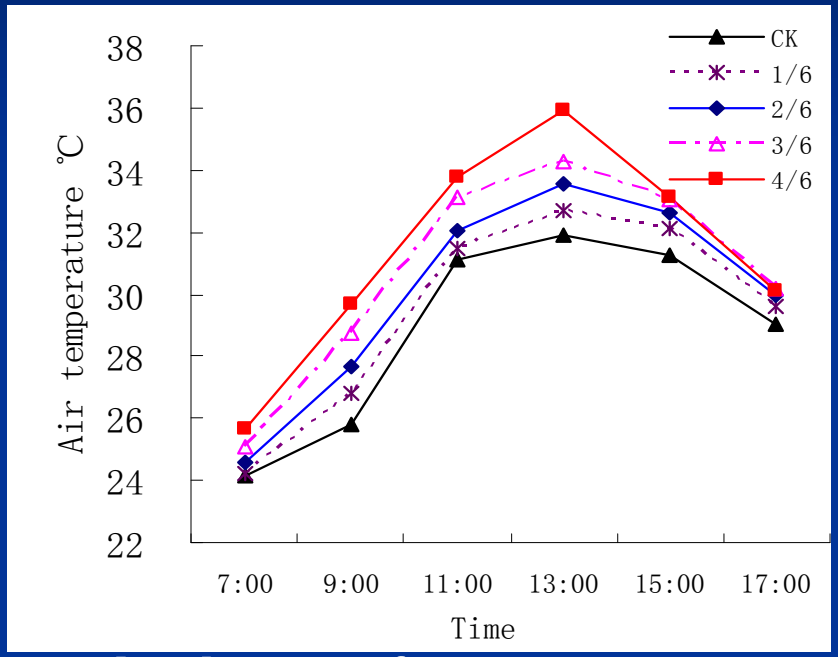
Effects of pruning on sap flow



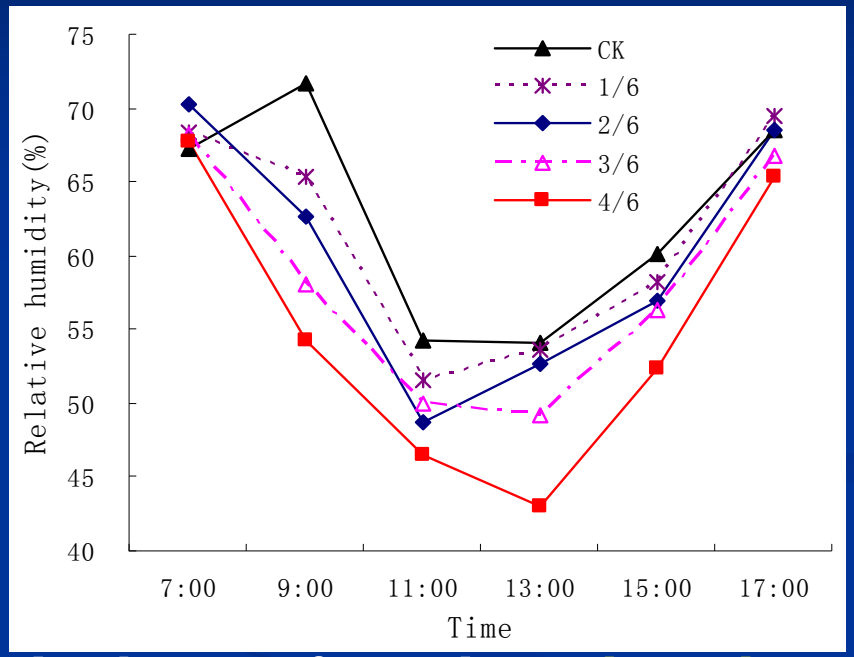
Daily dynamic of sap flow rate in xylem

Pruning decreased the stem sap flow rate, and significantly decreased the total water volume used for transpiration at individual tree level. This is very important in the North China regions, where the water resources is short.

Effects of pruning on the air temperature and relative humidity under canopy



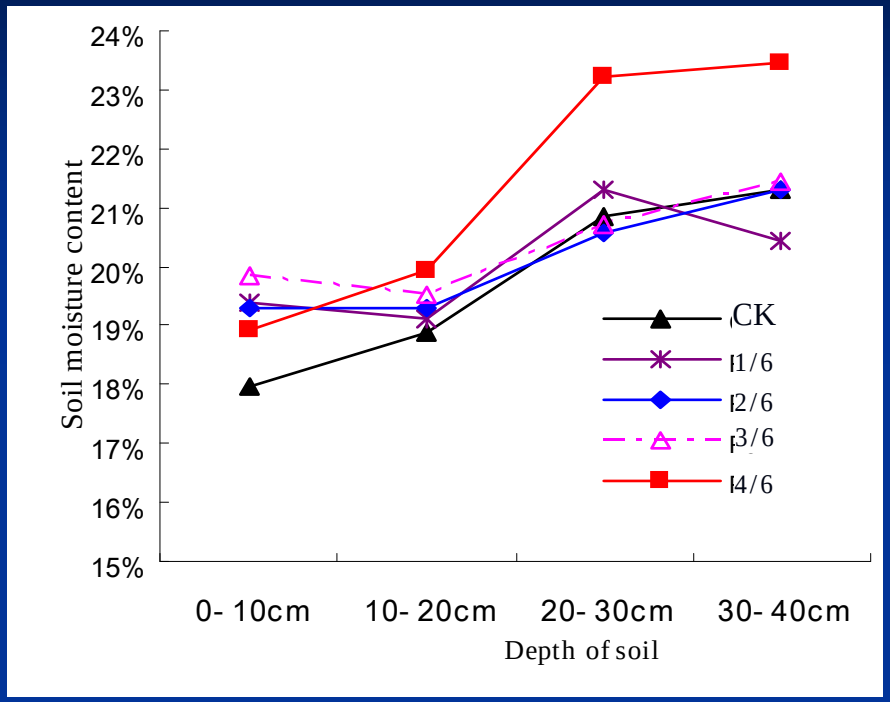
Daily change of air temperature inside the stand under different pruning treatment



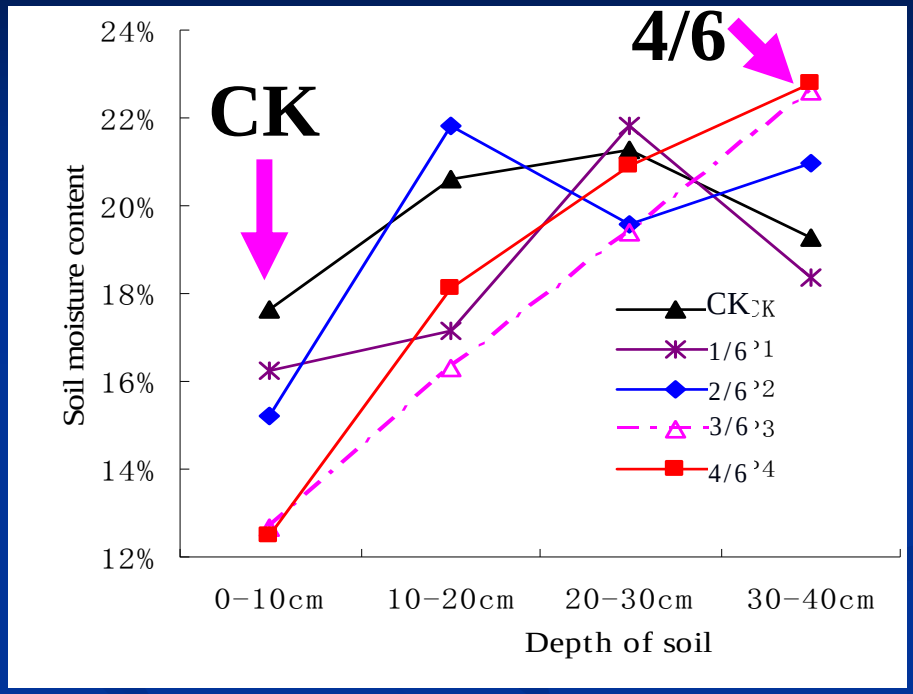
Daily change of air relative humidity inside the stand under different pruning treatment

Due to the increased PAR under the canopy, the air temperature increased and the relative humidity decreased inside the stand.

The effects of pruning on the soil water content under canopy



Water content after rainfall

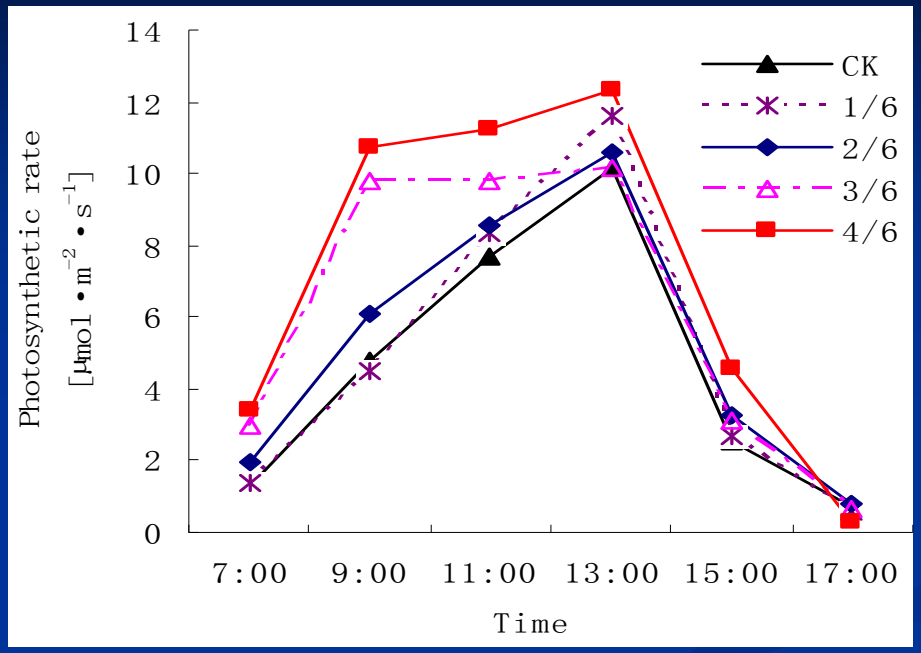


Water content one week later after rainfall

Due to the decrease of total transpiration, the pruning can increase the water content in the deep soil layer (30-40cm), alleviate the competition on the ground water between crops.

Effects of pruning on the crop net photosynthetic rate

wheat

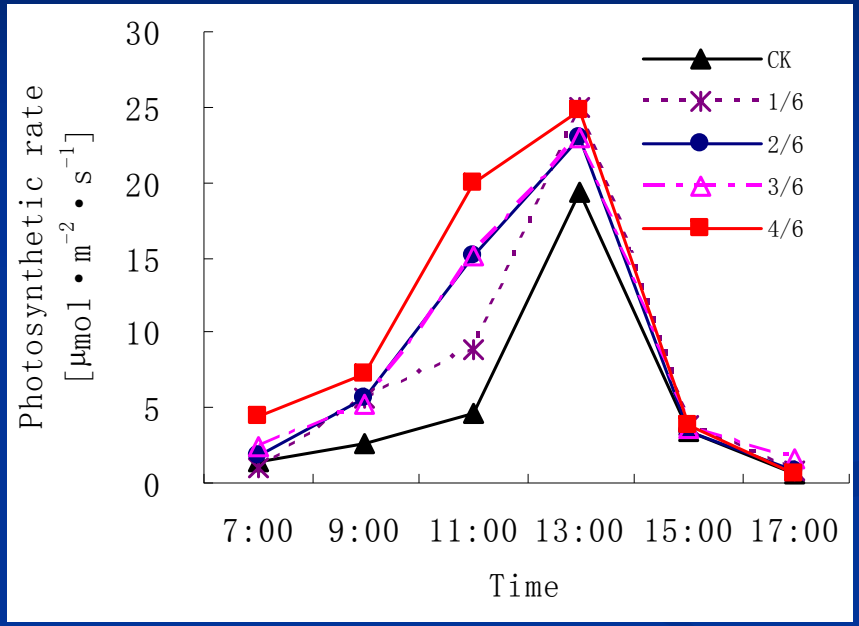


Daily change of wheat photosynthetic rate under different pruning treatment

Because of the increase of PAR, the crop net photosynthetic rate was increased after pruning. Compared with CK, the daily photosynthetic rate of wheat under 1/6、2/6、3/6、4/6 treatment was increased by 7.08%、14.95%、34.08%、56.38% respectively。

Effects of pruning on the crop net photosynthetic rate

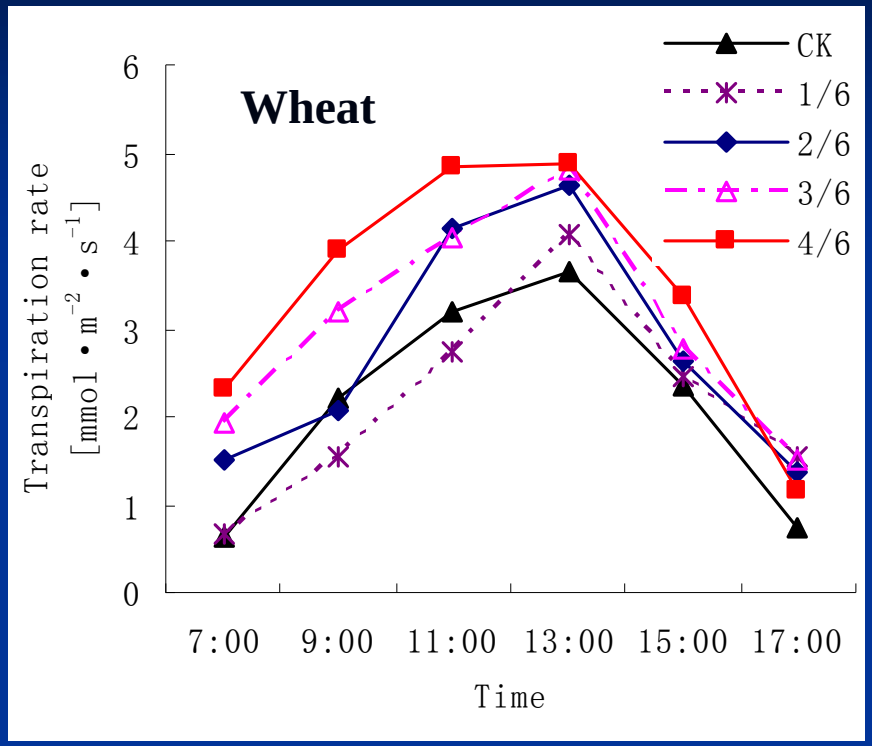
maize

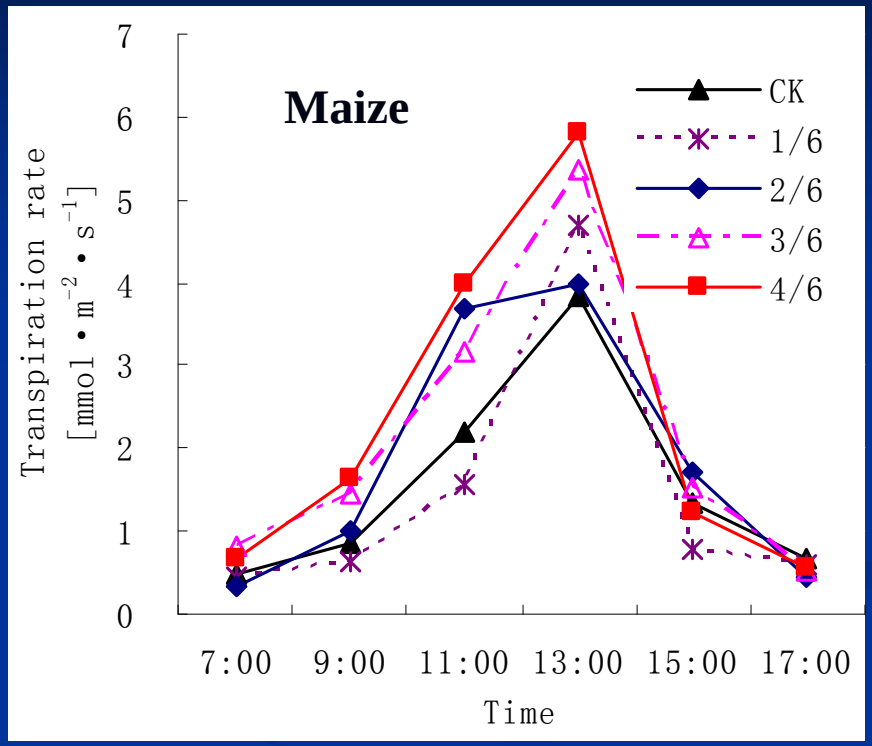


Daily change of maize photosynthetic rate under different pruning treatment

Compared with Ck, the daily photosynthetic rate of maize under 1/6、2/6、3/6、4/6 treatment was increased by 41.84%、56.20%、59.59%、90.78% respectively。

Effects of Pruning on leaf transpiration rate of crop





The daily change of leaf transpiration rate of crop under different pruning treatment

Compared with CK, the daily transpiration rate of wheat under 1/6、2/6、3/6、4/6 treatment was increased by 1.86%、28.04%、42.80%、68.53%; and 7.23%、19.79%、37.85%、48.81% for maize.

Effects of pruning on the height growth of crops under canopy

The height of wheat under different pruning treatment：from left to right Were:monoculture、4/6、3/6、2/6、1/6、CK

The height of maize under different pruning treatment：from left to right were: 4/6、3/6、2/6、1/6、CK

4/6 3/6 2/6 1/6 CK

satiation ← shriveled

The significant change on the production and seed satiation of crop after pruning

The effects of pruning on the under canopy crop production

Pruning treatment	Winter wheat				Summer maize			
	Spike number ($\times 10^4 \cdot hm^{-2}$)	Kernel number per spike	One thousand kernel weight (g)	Production ($kg \cdot hm^{-2}$)	Spike number ($\times 10^4 \cdot hm^{-2}$)	Kernel number per spike	One thousand kernel weight (g)	Production ($kg \cdot hm^{-2}$)
CK	187.3	22.2	23.76	898.6	58.36	32.49	216.25	189.6
1/6	197.3	23.5	25.81	995.2	85.04	32.53	234.62	276.6
2/6	203.0	24.2	28.52	1594.0	98.38	38.54	236.47	379.1
3/6	228.5	30.3	34.43	2025.9	156.75	39.10	257.19	630.4
4/6	243.4	28.1	38.00	2435.2	241.79	40.22	275.75	945.4

The wheat production increased by 10.75%~171.00%，and the maize production increased by 46%~399%.The spike number, kernel number per spike, one thousand kernel weight increased by 5.34%~29.95%、5.86%~36.49%、8.63%~59.93% respectively，as to the maize, the above three indicators increased by 45.72%~314.31%、0.12%~23.79%、8.5%~27.51% respectively.

Conclusions

To sum up,

1. **Pruning changed the microclimate**

Pruning treatment can effectively changed the microclimate under canopy,(such as increased the PAR, air temperature, soil water content and decreased the relative humidity.)

2. **Pruning changed the tree**

- The pruning treatment had no effects on tree height increment, but significantly decreased DBH increment.
- Pruning can effectively increased the leaf net photosynthetic rate.
- Pruning decreased the stem sap flow rate, and significantly decreased the total water volume used for transpiration at individual tree level.

Conclusions

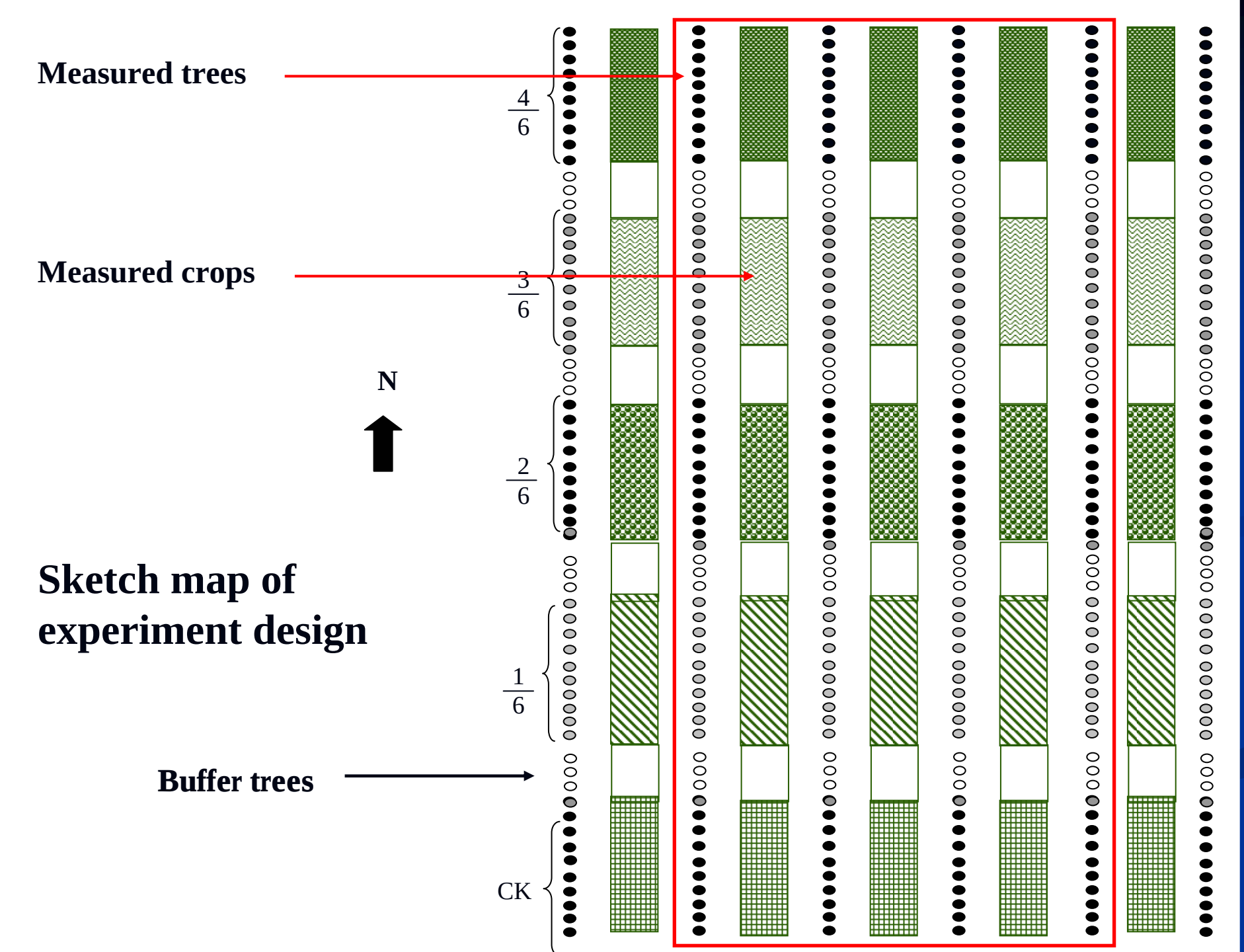
3.Pruning changed the crop

- **The crop net photosynthetic rate and transpiration rate were increased after pruning**
- **Pruning treatment can effectively improved the crop biomass and production.**

4. Integrated the research results,

Pruning decreased the tree taper and increased the volume, and the medium pruning intensity (2/6 treatment) had the highest relative volume increment.

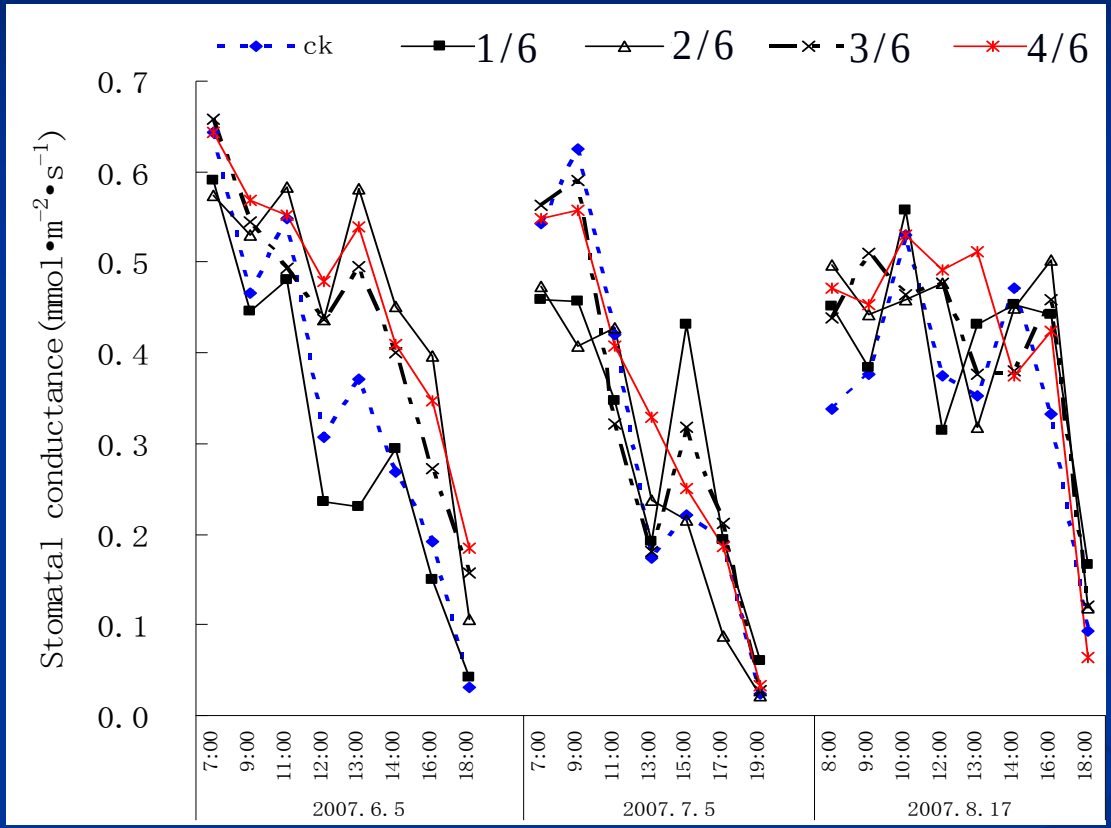
Thank You!



Sketch map of experiment design

Effects of pruning on stomatal conductance

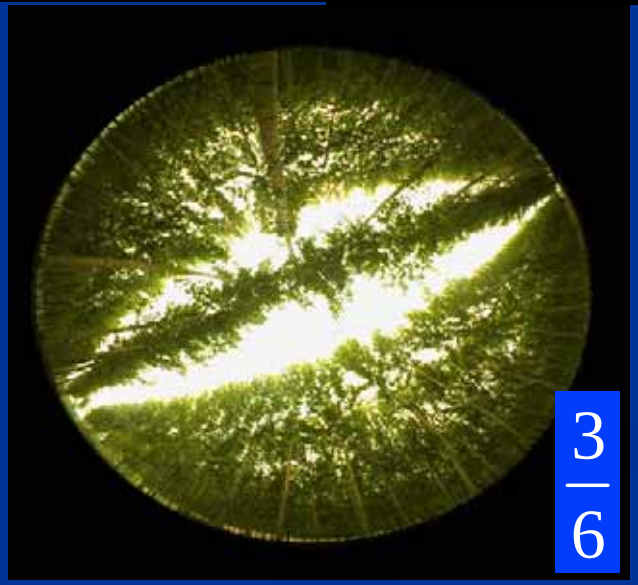
Daily change of stomatal conductance(mmol•m^{-2}•s^{-1})

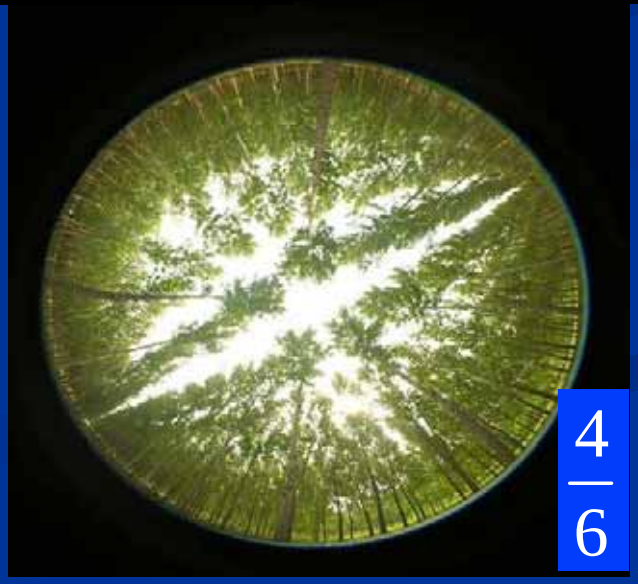


June 5, 2007 **July 5, 2007** **Au.17, 2007**

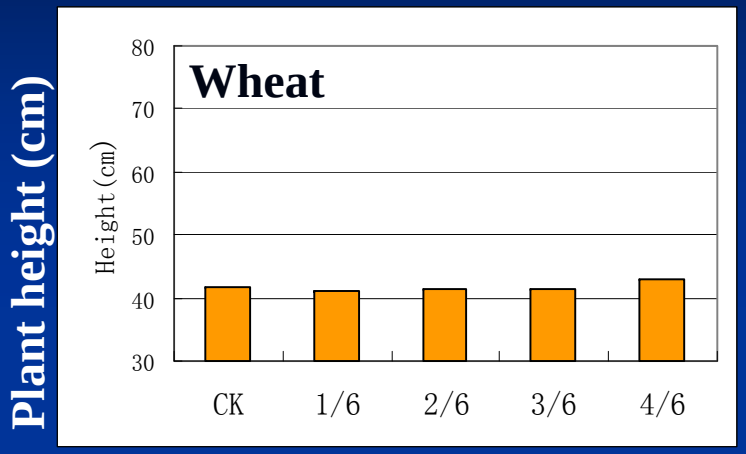
Pruning increased the leaf stomatal conductance and decrease the vapor pressure deficit at some degree, and helpful to the increase of net photosynthetic and transpiration rate.

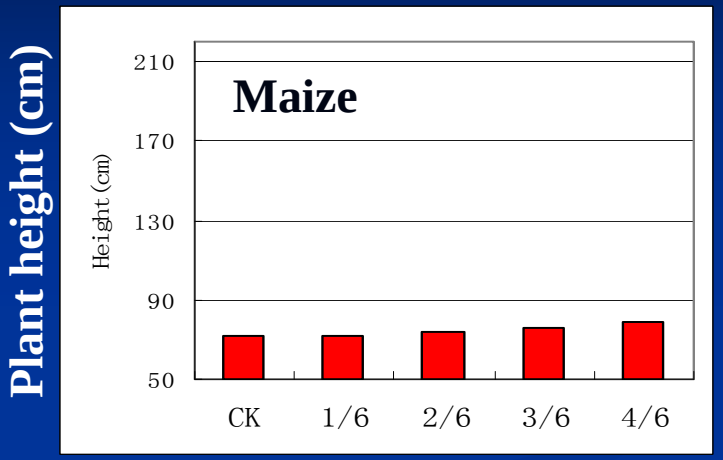
Hemisphere photos of canopy under different pruning treatment



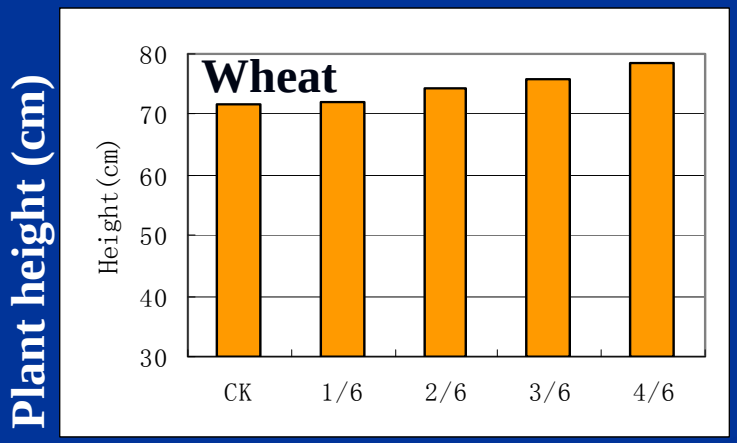


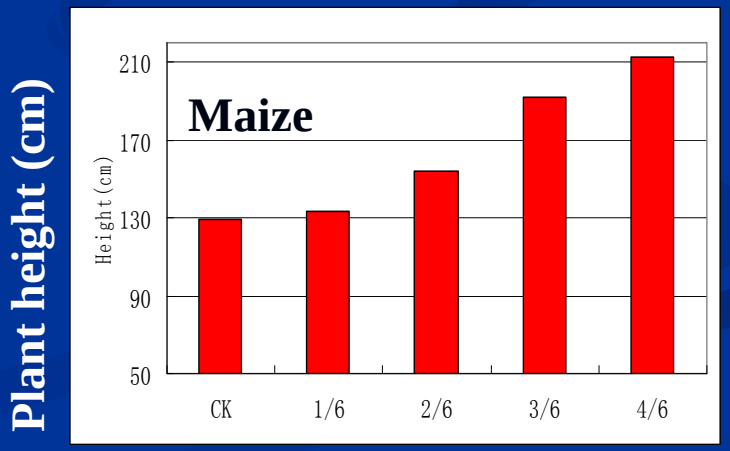
Effects of pruning on the height growth of under canopy crops





Individual plant height at **jointing stage**

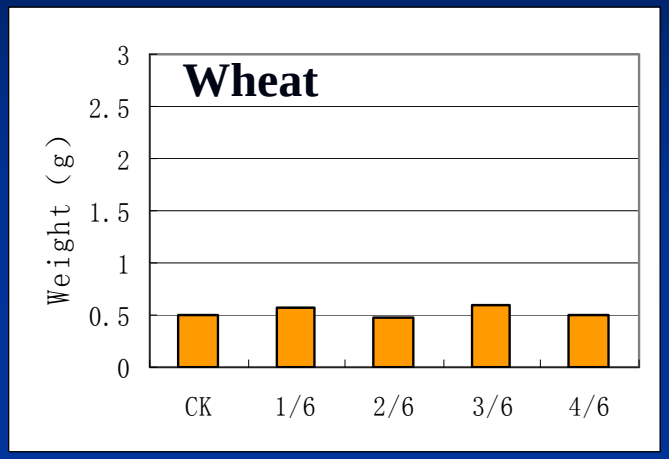


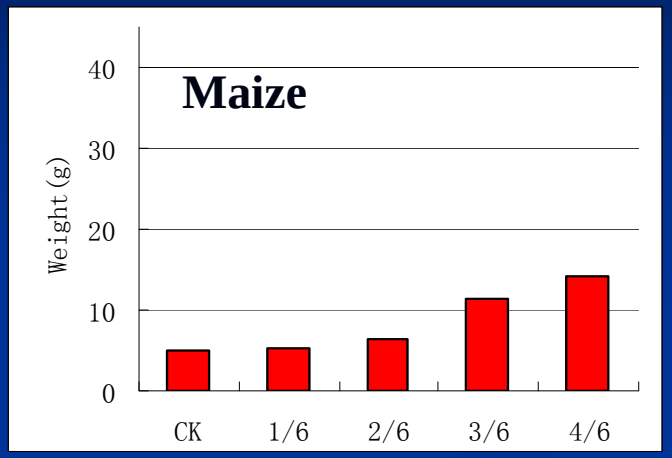


Individual plant height at **grain filling stage**

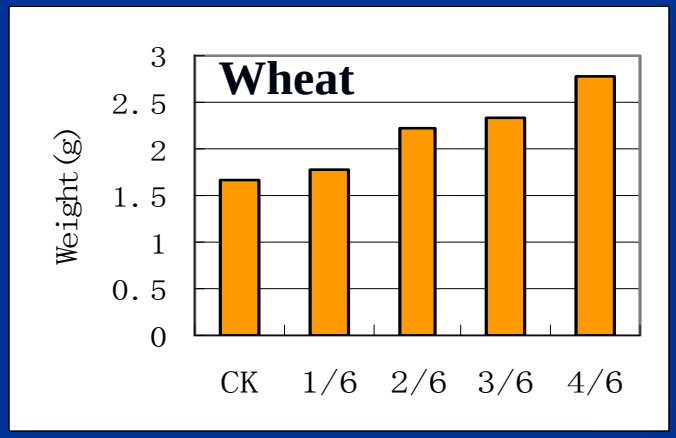
Individual plant height at **anthesis**

Effects of pruning on the stem and leaf biomass of under canopy crops

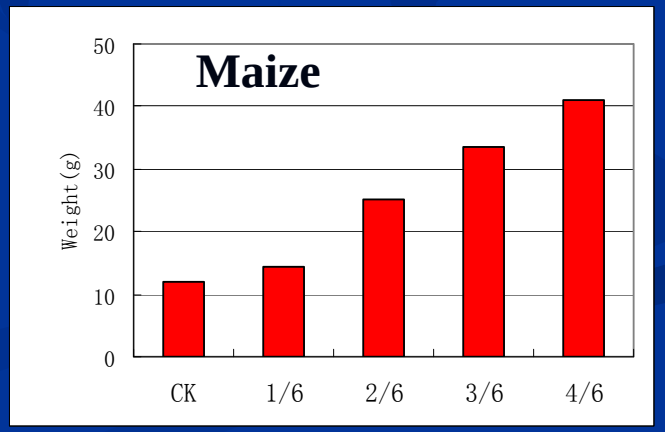




Stem and leaf biomass at **jointing stage**



Stem and leaf biomass at **grain filling stage**



Stem and leaf biomass at **anthesis**

The relative height increment of crops under different pruning treatment

phenological stage	Pruning treatment	Wheat	Maize
jointing stage	1/6	-1.68%	5.51%
	2/6	-0.96%	6.99%
	3/6	-0.48%	17.65%
	4/6	3.36%	19.73%
grain filling stage (Anthesis)	1/6	0.70%	3.57%
	2/6	3.63%	19.07%
	3/6	5.72%	48.92%
	4/6	9.34%	64.50%

The relative biomass increment of crops under different pruning treatment

phenological stage	Pruning treatment	Wheat	Maize
jointing stage	1/6	14%	5.99%
	2/6	-4.00%	32.93%
	3/6	18%	40.12%
	4/6	-2.00%	67.07%
grain filling stage (anthesis)	1/6	2.55%	21.00%
	2/6	27.84%	110.88%
	3/6	125.49%	180.67%
	4/6	178.24%	242.01%

Conclusions

- The pruning treatment had no effects on tree height increment, but significantly decreased DBH increment.
- However, the diameter growth at the top crown section was increased, therefore decreased the tree taper and increased the volume, and the medium pruning intensity (2/6 treatment) had the highest relative volume increment.
- Pruning can effectively increased the leaf net photosynthetic rate and transpiration rate at top crown, especially under the drought condition.

Conclusions

- **Pruning decreased the stem sap flow rate, and significantly decreased the total water volume used for transpiration at individual tree level.**
- **Pruning increased the leaf stomatal conductance and decrease the vapor pressure deficit at some degree, and helpful to the increase of net photosynthetic and transpiration rate.**
- **Pruning treatment can effectively changed the microclimate under canopy, such as increased the PAR, air temperature, soil water content and decreased the relative humidity.**

Conclusions

- The crop net photosynthetic rate and transpiration rate were increased after pruning, as well as the stomatal conductance and the stomatal limitation value.
- Pruning treatment can effectively improved the individual plant height, biomass and the crop production.
- Integrated the research results, the medium pruning intensity is suitable in the poplar agroforestry system in China.

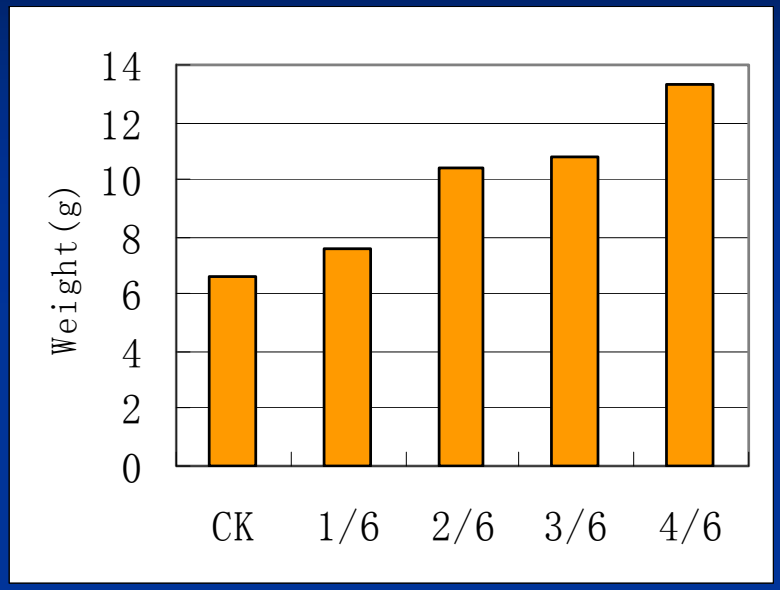
Future Research

- The dynamic responses of trees growth and physiological processes to pruning
- The effects of pruning on the knots and lumber recovery
- The effects of pruning on the wood attributes such as wood density and cellulose length.
- The economic benefits in the poplar agroforestry system

Acknowledgement

- The research was financially supported by the Agriculture Scientific and Technological Achievement Transform Fund (05EFN217100430) — “Application of the Cultivation Techniques of High Yield Euramerican Poplar Plantation”
- Thanks to Senkun Chen, Shangwei Sun, Drs. Xinli Xia and Xiaodong Liu for their contribution to this project.

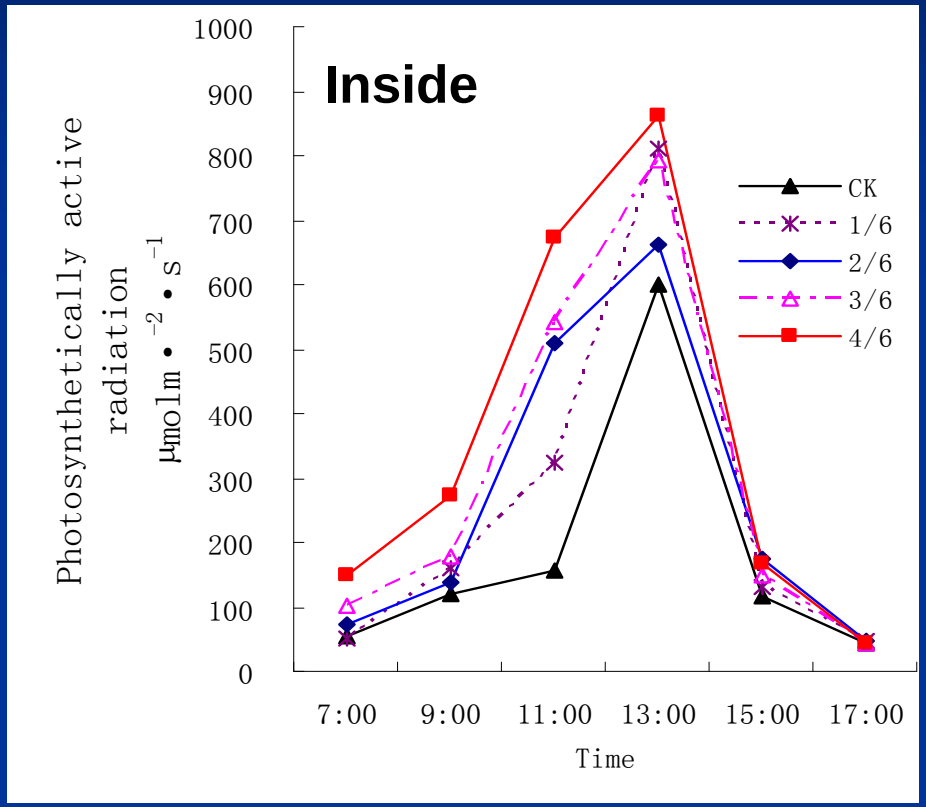
The effects of pruning on the spike dry weight of winter wheat

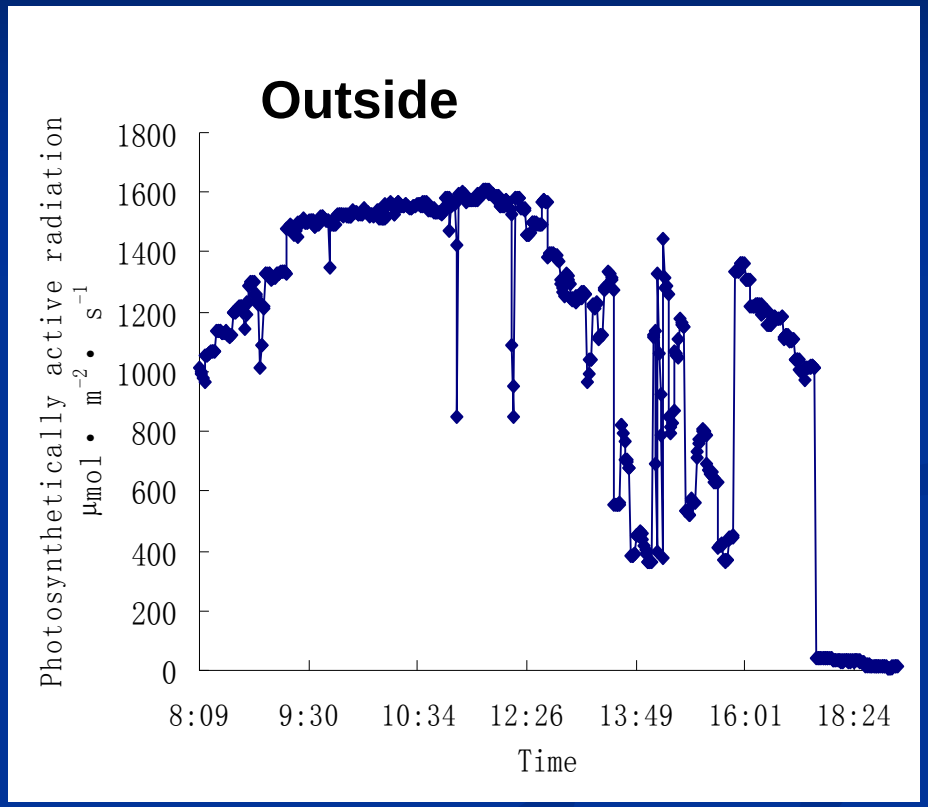


Wheat spike dry weight at grain filling stage under different pruning treatment

Because of the microclimate change, the pruning can effectively improved the crop production, compared with CK, the wheat spike dry weight under 1/6、2/6、3/6、4/6 treatment was increased by14.70%、57.58%、63.64%、101.82%.

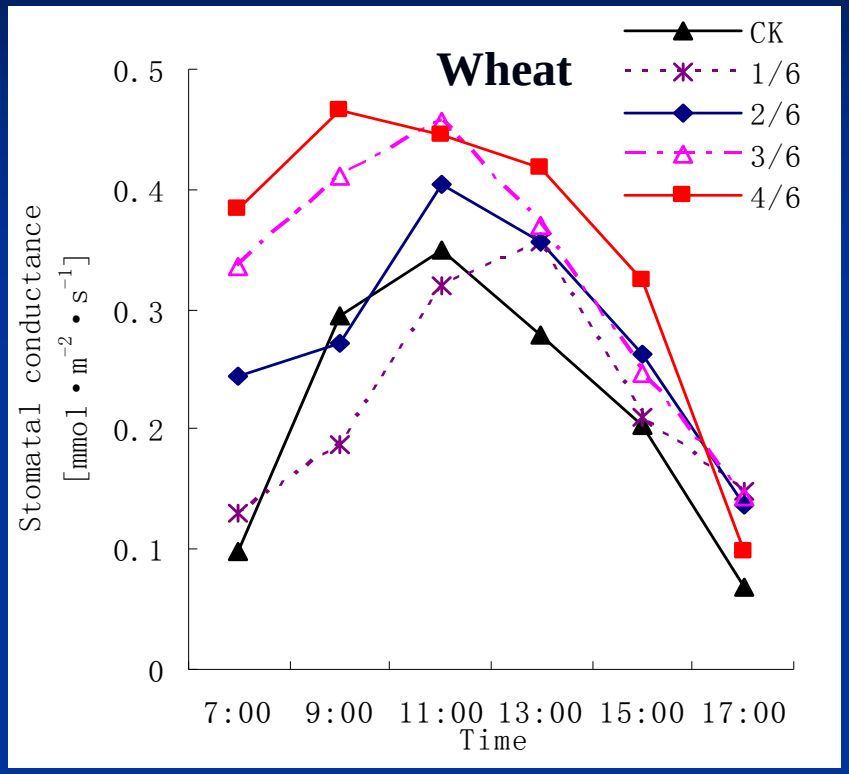
Effects of pruning on the Photosynthetically Active Radiation (PAR) under the canopy

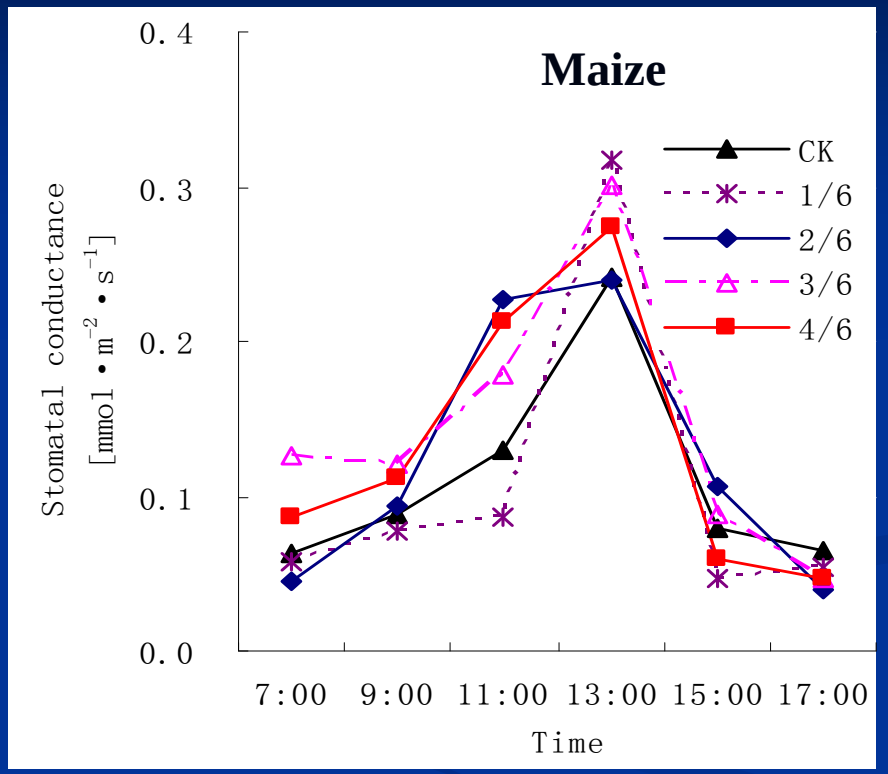




Different pruning treatment(1/6, 2/6, 3/6, 4/6) can effectively increase the PAR between forest belt by 39.7%,47.1%,65.7% and 98.9%.

The effects of pruning on the crop stomatal conductance

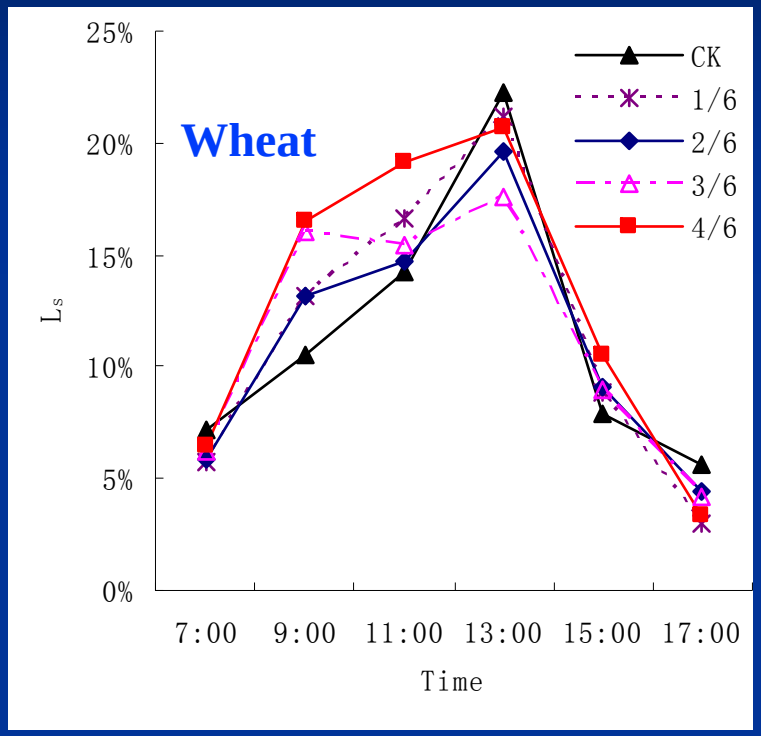


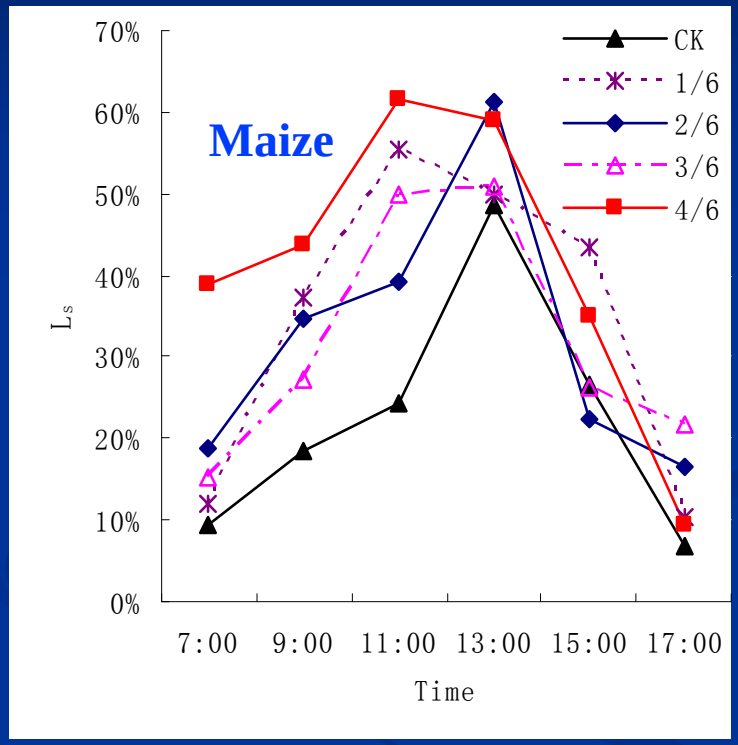


Daily change of crop stomatal conductance under different pruning treatment

The stomatal conductance increased after pruning

The effects of pruning on the crop stomatal limitation value





Daily change of crop stomatal limitation value under different pruning treatment

The stomatal limitation value increased after pruning, this indicated that the crop photosynthesis limited factors changed from non-stomata factors to stomata factor.