Integrated soil–crop system management for food security

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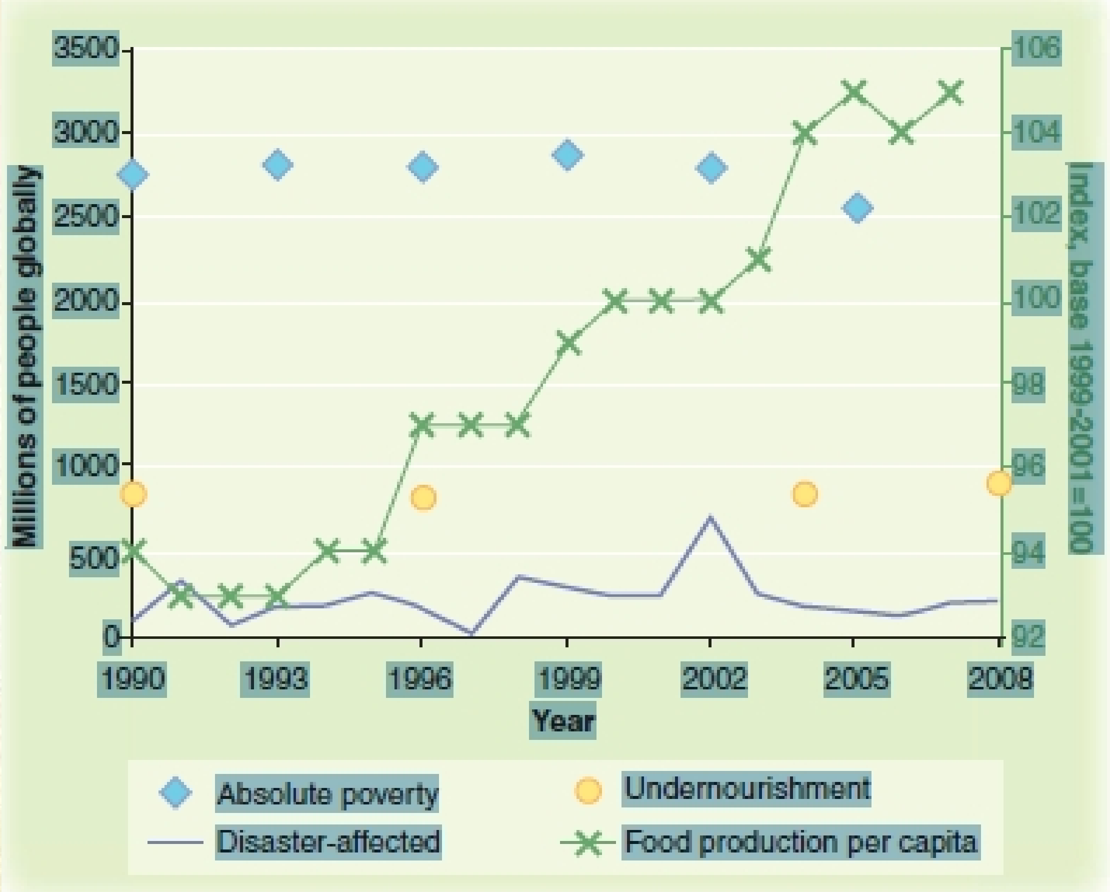
Background and Objectives

➢Background

- Recently the challenges of ensuring global food security have received increasing attention from the scientific community.



From Barrett CB (2010) Measuring food insecurity. Science 327:825–828.

Background and Objectives

➢Background

- Recently the challenges of ensuring global food security have received increasing attention from the scientific community.
- Research on intensive grain-production systems in the developed economies has focused on adding new pruducts to agricultural systems, and on technologies that make farming less costly or less damaging to the environment.
- It will be necessary to increase yields substantially and to distribute those yields more effectively for the countries where hunger and malnutrition.
- Populations are continuing to grow rapidly in China and other rapidly developing economies. Moreover, all are increasing demands for food. Chinese cereal grain yields increased by 10% from 1996 to 2005, whereas the use of chemical fertilizers increased by 51%. This nutrient imbalance in turn drives environmental pollution problems, such as eutrophication , greenhouse gas emissions and soil acidification.

Background and Objectives

Background

- China and other rapidly developing economies face the challenge of how to greatly increase grain cereals and less damage to the environment .
- Several conceptual frameworks have been proposed to increase potential yields and reduce environmental consequences of intensive agriculture. For example ecological intensification. Although there is agreement on the need for such improvement ,there are few examples of how they can be developed and adapted across hundreds of millions of farmers fields.

Objectives

- Increase intensive agriculture cereal crop yields
- Reduce damage to the environment in the intensive agricultural production processes
- Applied to hundreds of millions of smallholder production

Materials and Methods

➢Study Areas

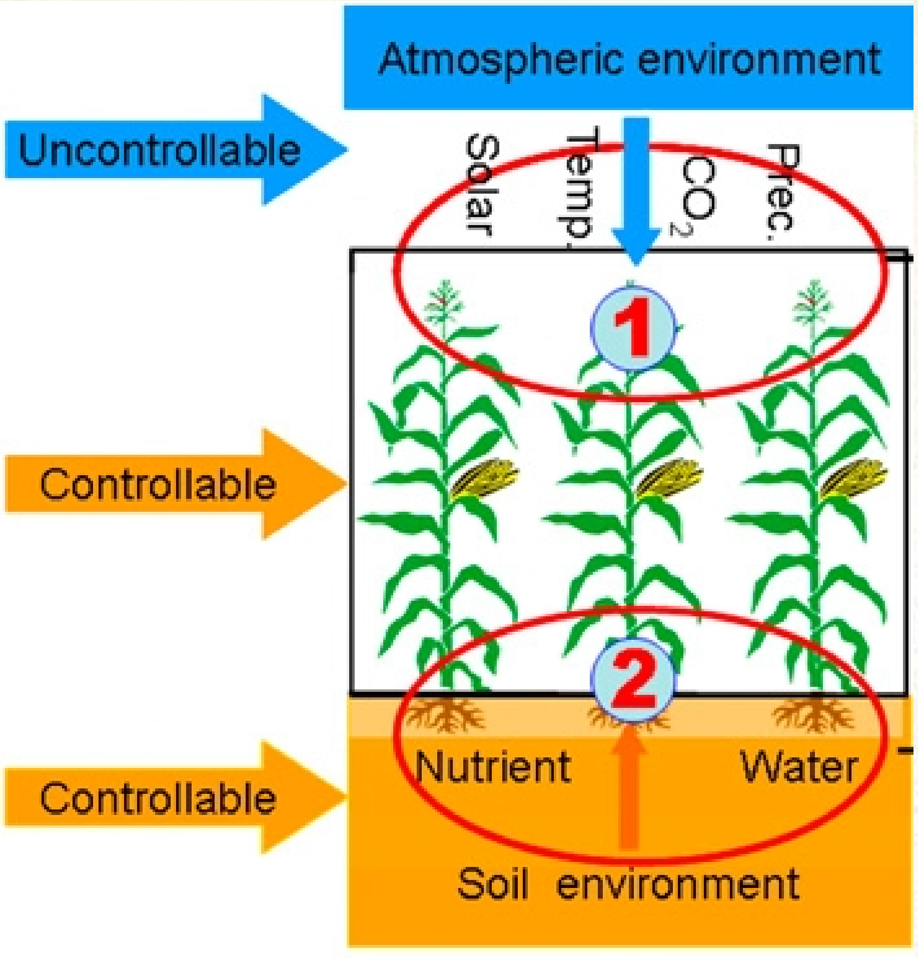
Main maize production areas in China			
Regions	Northeast	Northwest	North China Plain in central-eastern China
Site	45-55 °N，110-125 °E	34-40 °N，105-115 °E	32-41 °N，113-120 °E
Test Points	11	39	16
Cropping Systems	Spring maize	Spring maize	Rotation (wheat and maize)

➢Methods

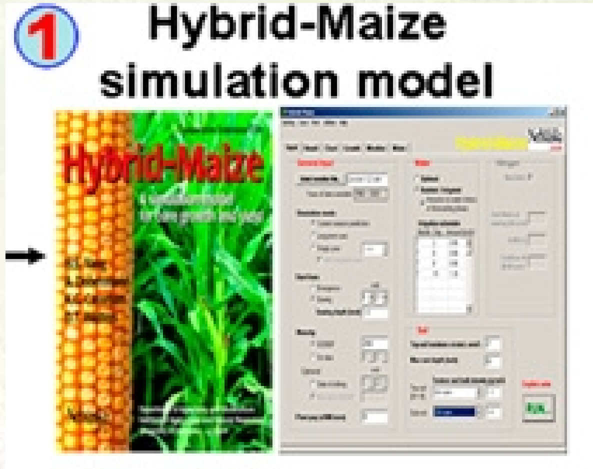
Integrated Soil-Crop System Management (ISSM)

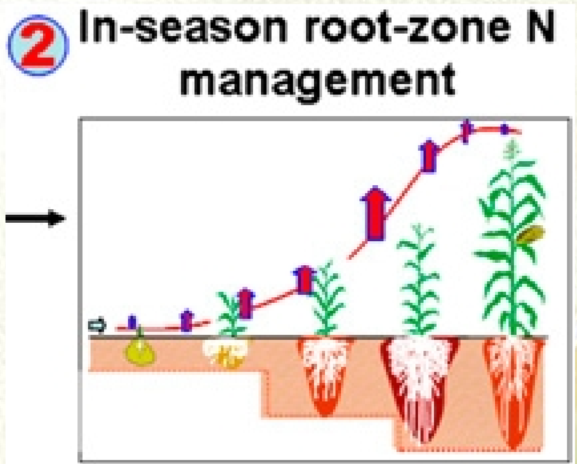
- Crop Management—Hybrid-Maize simulation model Identify the most appropriate combination of planting date, crop density and plant variety
- Soil Management—In-season root-zone N manageement (IRNM) Ensure N supply and crop N demand balance, reduce environmental damage.

Materials and Methods



Conceptual framework for the ISSM approach





Materials and Methods

➢Nitrogen fertilizer management

	Maize Growth Period				
	Planting-six leaf stage(V_6)	V_6-ten leaf stage (V_{10})	V_{10}-anthesis (R_1)	R_1-blister (R_2)	R_2-physiological maturity(R_6)
Target N value (kg ha^{-1})	80	130	130	140	120

➢Comparative Test

- Farmers Practice（FP）
- High Yielding Studies（HY）

Results and Discussions

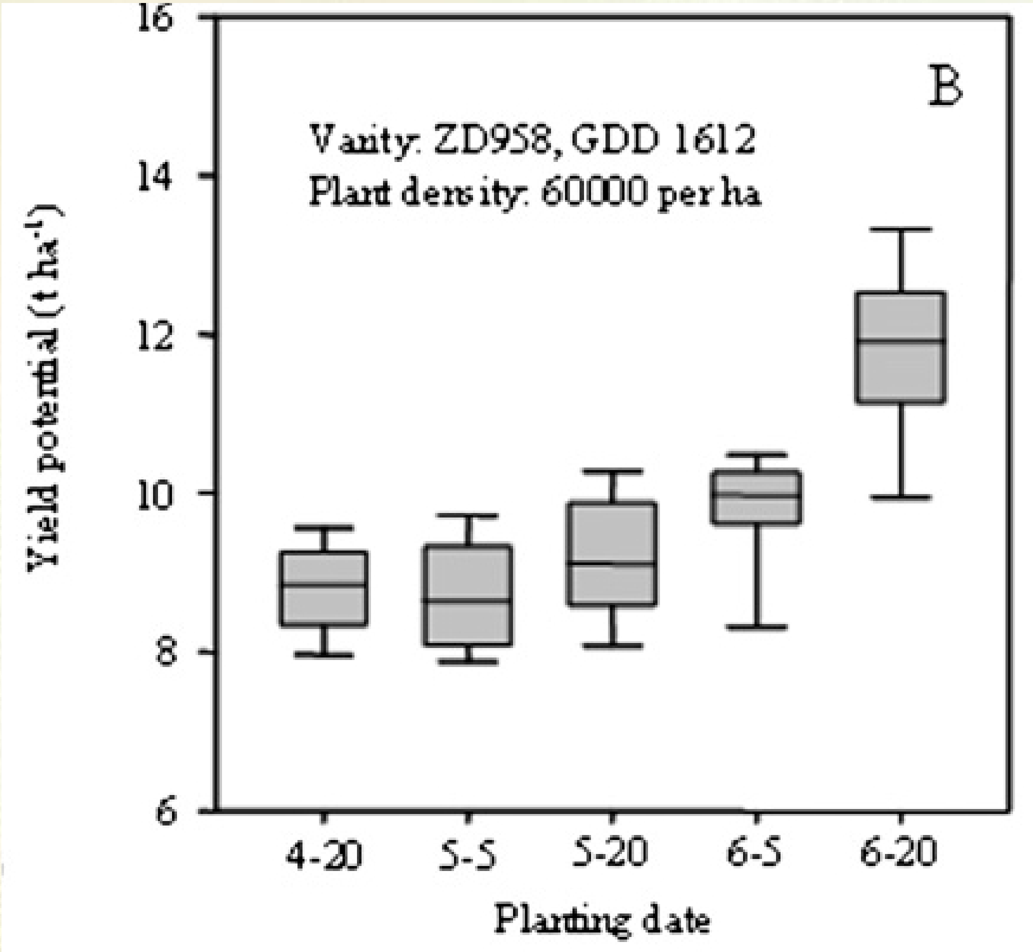


Figure 1 Influence of planting date on yield potential

Results and Discussions

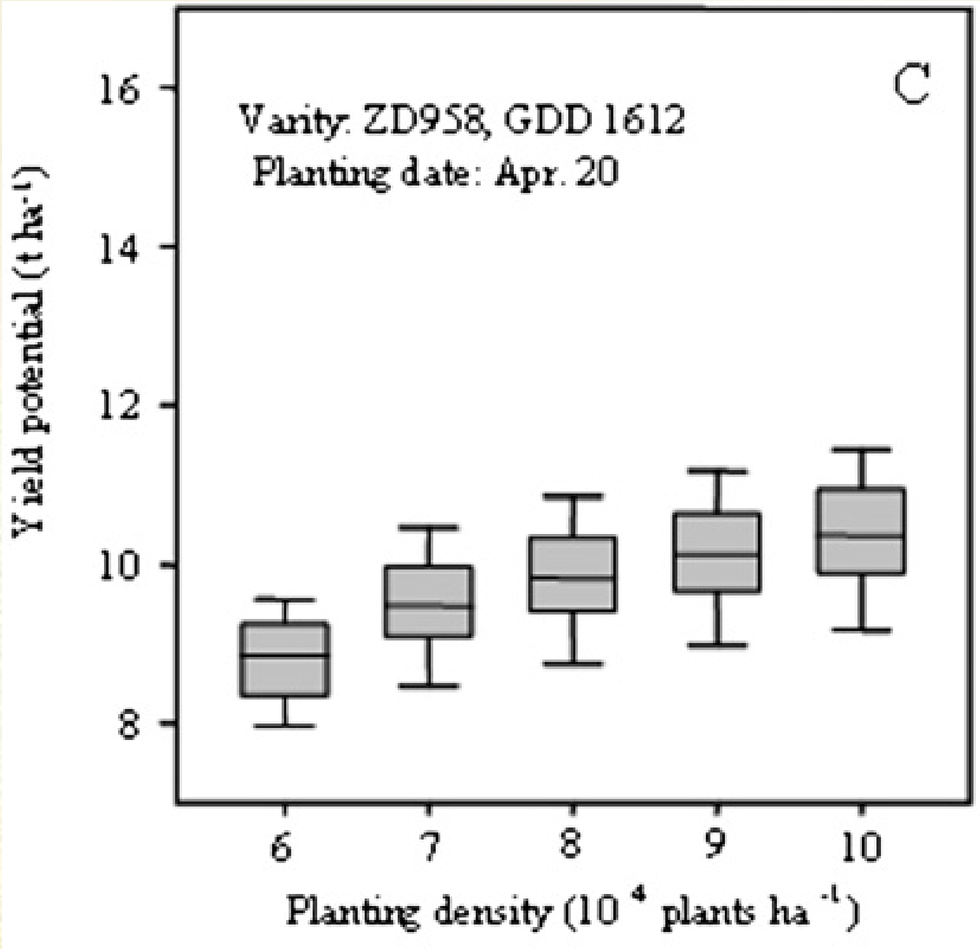


Figure 2 Influence of planting density on yield potential

Results and Discussions

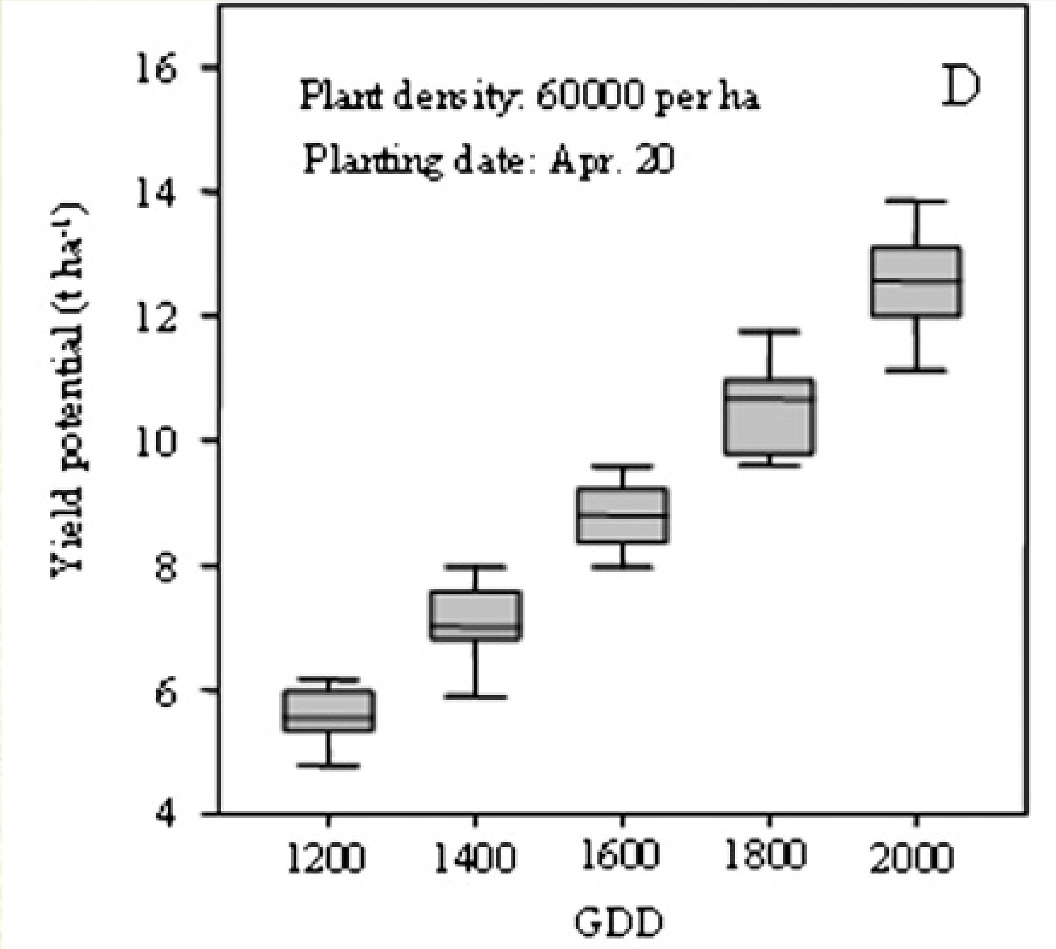
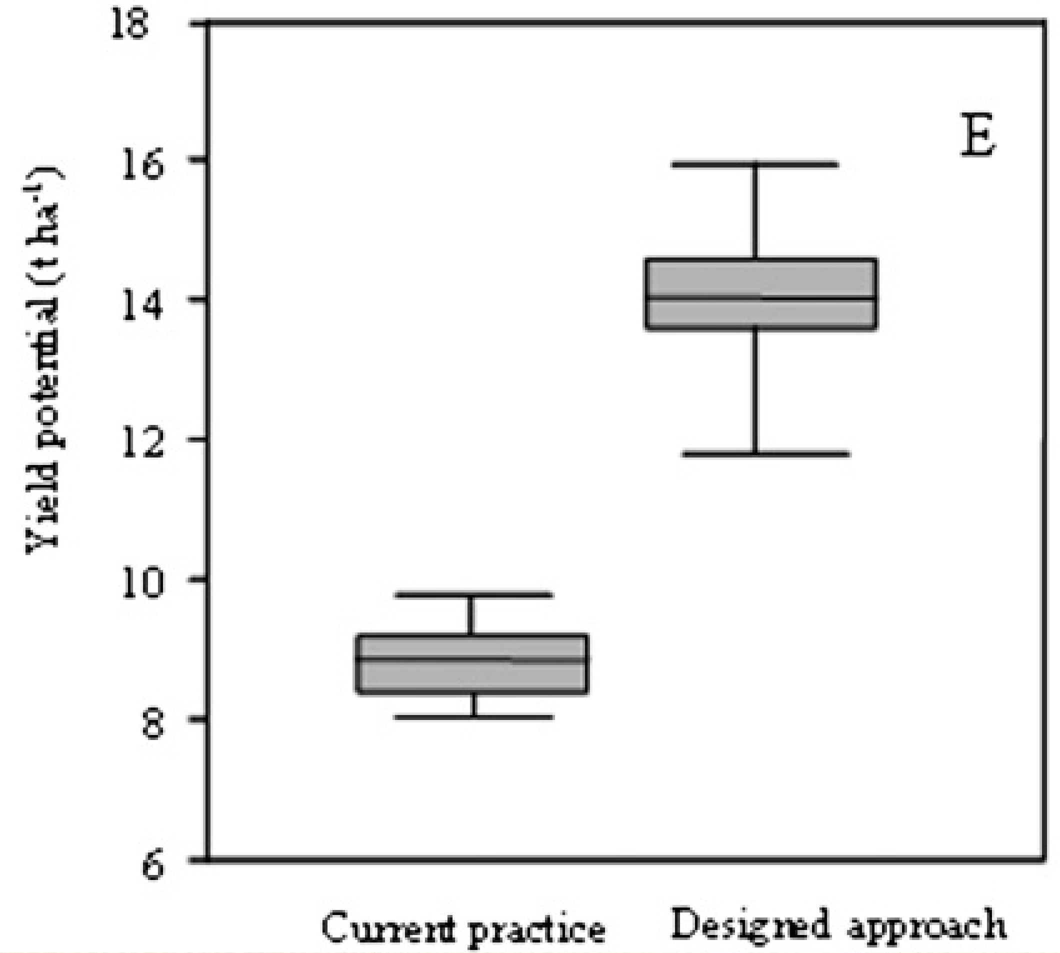


Figure 3 Influence of crop varieties that differ in GDD requirements on yield potential

Results and Discussions

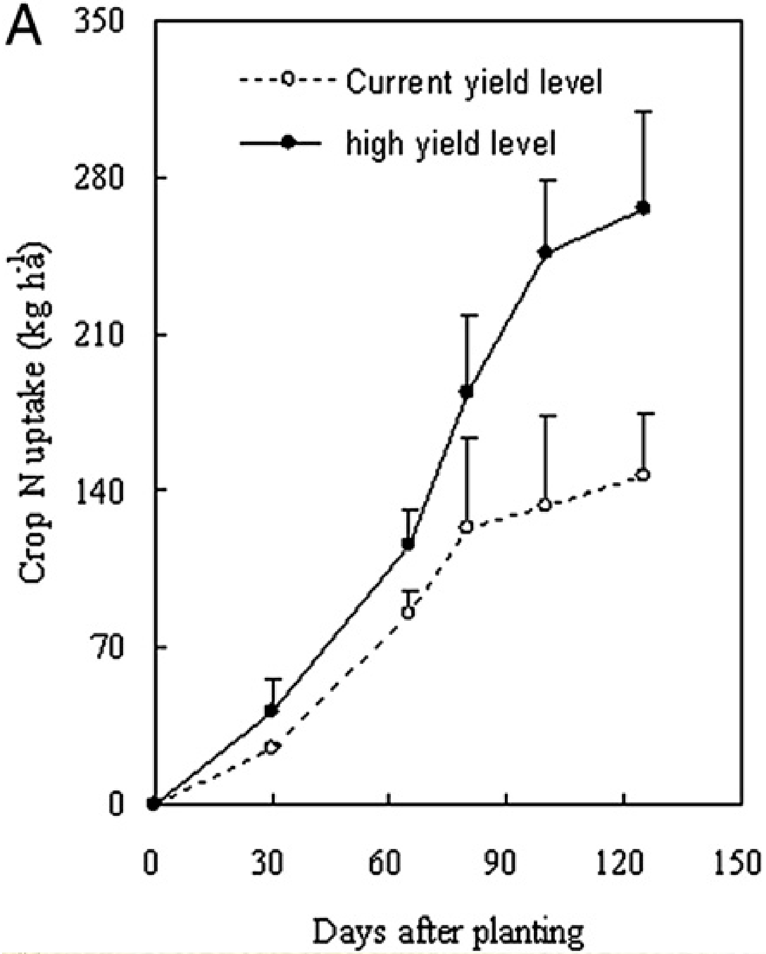


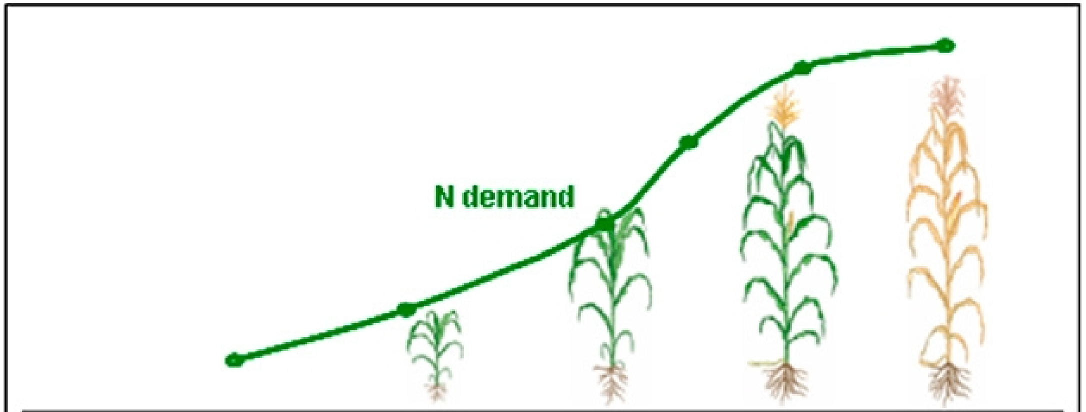
Current practice
Maize varieties : ZD958，GDD 1612
Planting date : April 20
Planting density : 60000 per ha

Designed approach
Maize varieties : DH3719，GDD 1952
Planting date :April 28
Planting density : 100000 per ha

Figure 4 Integrated effects of the optimal combination of factors

Results and Discussions





Growing stage	Planting-V_6	V_6-V_{10}	V_{10}-R_1	R_1-R_2	R_2-R_6
Depth of root-zone (cm)	0-30	0-60	0-90	0-90	0-90
Target N value (kg N ha^{-1})	80	130	130	140	120
N fertilizer rate (kg N ha^{-1})	68	52	30	30	45

Figure 5 (A)Timing of N uptake by maize grown； (B) N application and requirment for each maize period

Results and Discussions

Table 1. Mean maize grain yield and modeled yield potential, N balance,and N applied per unit of grain produced for different management systems

Variable	ISSM n=66	HY n=43	FP n=4548
Maize grain yield（$t\ ha^{-1}$）	13.0±1.6	15.2±2.6	6.8±1.6
Yield potential（$t\ ha^{-1}$）	15.1±1.9	16.8±2.0	—
Yield potential（%）	86	91	—
N input from fertilizer（$kg\ ha^{-1}$）	237±70	747±179	257±121
N removal（$kg\ ha^{-1}$）	250±31	292±50	132±31
Input minus harvest removal ($kg\ ha^{-1}$)	-12±56	457±155	127±42
Yield per unit fertilizer N applied ($kg\ kg^{1}$)	57±13	21±5	26±20

Some of questions need to be addressed about ISSM adapted across hundreds of millions of farmers′ fields

- **Biophysical**

A. How close to the yield potential can average farm yields rise while maintaining efficient use of applied inputs?

B. What are tolerable thresholds for losses of nitrogen to ground- and surface water and to the atmosphere?

C. Is it possible to sequester carbon in high-yield, high-efficiency production systems?

- **Policy oriented**

A. How can farmers obtain the information necessary to apply the ISSM system?

B. What are the barriers to implementation by individual farmers, and how can they be alleviated?

C. How can knowledge about these approaches most effectively be shared and integrated into the knowledge base of farmers?

Conclusion

- ❖ ISSM approach achieved mean maize yields of 13.0 t ha^{-1} on 66 on-farm experimental plots—nearly twice the yield of current farmers′ practices.
- ❖ ISSM approacht increased yields of cereal grains while at the same time no increasing N fertilizer use.
- ❖ISSM approach reduced the invironmental impacts in the intensive agricultural production processes.

Thanks