Establishing a sustainable crop production system for the North China Plain

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Abstract*:*

Water resource shortage and low nitrogen fertilizer use efficiency are the main limiting factors in the conventional winter wheat-summer maize rotation system in the North China Plain. Establishing a high yielding, water saving and N use efficient crop production system is urgent needed. In this study, "Hybrid-Maize Model" was validated and introduced to establish a spring maize production system with high-yielding (target yield>12 t/ha) and water saving (target water consumption < 550 mm/yr), to instead of the conventional winter wheat-summer maize rotation system, a real-time nitrogen management strategy was used to improve nitrogen use efficiency for this spring maize production system. In multi-locations and years experiments, the productivity, water balance and water use efficiency, N use efficiency were measured. Preliminary results indicated that the new spring maize production system had significant advantage in water and N use efficiency. Results on productivity, water and N balance were also presented and discussed.

Media summary

Present a spring maize production system with high yield and sustainable water resource use to instead of the conventional winter wheat-summer maize rotation system in the North China Plain .

Key words
North China Plain, spring maize, N use efficiency, water use efficiency, Hybrid-Maize model

Introduction

The North China Plain is one of the most important area of crop production in China and produces 61% of wheat and 31% of maize of the total nation. Winter wheat / summer maize double cropping system in one year is the main cropping system in this region. However, a raising problem in this area is the limited water resource. The groundwater table in the whole North China Plain has decreased more than 10 meters in the past 10 years, main reason is assumed by the agriculture because of more than 70% groundwater was used for wheat irrigation. Data show that the total evapotranpiration of the double cropping system is 750 –

850 mm, which 200-300 mm higher than the long-term precipitation in the North China Plain. Therefore, it is obviously that this conventional winter wheat / summer maize rotation system can't sustainable. On other hand, over nitrogen fertilizer application and low N use efficiency is very common (Chen et al., 2006). In this study, we want to establish a spring maize production system with high-yielding and water saving, to instead of the conventional winter wheat-summer maize rotation system, and a real-time nitrogen management strategy was used to improve nitrogen use efficiency for this spring maize production system. Multi-locations and years field experiments were conducted to compare the productivity, water and N use efficiency between two crop systems.

Methods

1. Field experiments with conventional winter wheat / summer maize cropping system and new spring maize cropping system were conducted in two sites and two years, in order to study the water saving potential of the spring maize system.
2. Establishing a high yielding spring maize production system using the validated Hybrid-Maize model (Yang et al., 2004). Several field experiments were conducted with different planting pattern in multi-locations in the North China Plain.
3. Spring maize field experiments with different nitrogen treatments were conducted in order to establish a high yielding and high N use efficiency production system.

Results

1. Water saving potential and the groundwater balance of the different cropping systems.

Compared with the conventional farmers' practice, the reduced input treatment saved 58mm irrigation water. But all the double cropping systems consumed net groundwater 327 mm yr^{-1}. At the same time the single crop (spring maize) net groundwater consumption was only 149 mm yr^{-1}. However no cropping system can keep the groundwater balance during these two experimental years because of the dry weather condition. It decreased 100 mm precipitation comparing with normal. But anyway the spring maize production system was more sustainable than the double cropping system in point of water resource use view. However, if we compared the yield of the different cropping systems, the double cropping systems were still higher than the single one or three harvests in two years.

Tab.1 The water balance of the different cropping systems in 2 experimental sites and 2 growth seasons from Oct. 2004 to Sept. 2006 (mm)

Water Balance	Treatments			
	FP	RI	TW	CS
Irrigation	391	333	261	147
Precipitation	463	463	463	463
Etc	791	791	709	612
Drainage	64	5	16	-2
Balance (Dra.-Irr.)	-327	-327	-245	-149

1) FP: Winter wheat-summer maize rotation, farmers' practice (water and N input); RI: Winter wheat-summer maize rotation, reduced water and N input; TW: three harvests in two years, Winter wheat-summer maize / spring maize; CS: continuous spring maize in two years.
2) Etc: calculated by Penman-Monteith formula and crop factors (FAO).

2. Establishing a high yielding spring maize production system

The Hybrid-Maize Model was validated by the different planting pattern experiment established at Beijing in 2006 (Fig. 1). The dynamic stover yield is simulated well by Hybrid-Maize model for different treatments. For LAI, the model can reproduce the most measured data except for that at the silking stage (marked by red line in fig 1). The highest value for LAI was underestimated by model, especial for the high planting density. That simulation also was observed by original paper developed by Yang in 2004. Overall, the LAI and stover dynamics predicted by Hybrid-Maize model were close to observed values.

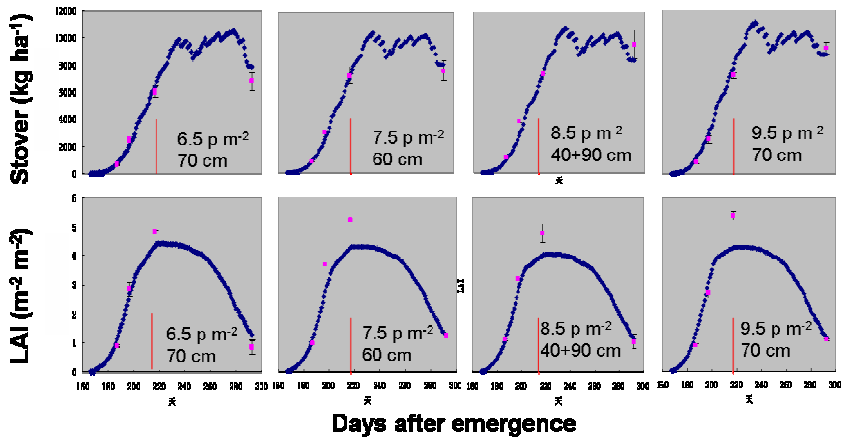

Fig.1. Observed (symbols and error bar = mean and S.E.) LAI and stover yield of maize and LAI predicted by Hybrid-Maize for four planting pattern treatments (D1, D2, D3 and D4) at Beijing in 2006. Vertical bars along the x-axis indicate the date of silking.

In our study, we used Hybrid-Maize model to design the high yield maize system and exploit the maize yield potential in North China Plain in 2005-2007. The results showed in table 2 demonstrated the average yield of 13.7 t/ha was realized in some locations simulated in the North China Plain. But we should noticed that the optimal crop and soil management also played a key role in the high yield experiments.

Table 2. The maize yield performance in multi-locationas and years by application of the Hybrid-Maize Model. M/S is the ratio of measured and simulated maize yield.

Site	Year	Grian Yield (t/ha, water content of 15.5%)			M/S %
		Long-term simulation	In-season simulation	Measured	
DBW	2005	13.5	14.1	12.1	86
DBW	2007	13.5	14.9	14.7	99
SZ	2007	19.6	17.8	13.3	75
CW	2007	14.9	14.6	14.7	101
AVE				13.7	

3. Improving the N fertilizer use efficiency in a high-yielding spring maize production system

Table 3 showed the results for different N application rate in high yielding setting. A yield of 9.7 t/ha was got in the no N treatment. That seemed to implicate the significance of high yield management for nitrogen management. It is very manifest that the treatment of Nopt+30% had a high yield (12.4 t/ha) and high NUE (57%) simultaneously and no statistical significance was tested between Nopt+30% and Ntr treatments.

Table 3. The N optimization experiment results for yield, N uptake, N rate and NUE in high yield spring maize system. Ntr represented the N application in traditional high yield experiment based on summarization of published paper. Nopt represented the optimal N recommended application based on Nmin methoded developed by Chen et al., 2006. CK is the no N treatment.

Treatment	Yield [a] t/ha	N uptake kg/ha	N rate kg/ha	NUE %
CK	9.7d	126	0	
Ntr	13.3a	254	450	28
Nopt	11c	234	160	68
Nopt+30%	12.4ab	245	208	57
Nopt-30%	11.3bc	200	112	66

[a] *ANOVA for test the yield difference at the significance of 0.05*

Conclusion

The multi-locations and years experiments results suggested the new spring maize cropping system had lower water consumption with high yield and high nitrogen use efficiency. But further research should be done on increasing yield level and sustainable resources using for this promising alternative cropping system.

References

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