Increasing nitrogen use efficiency by new designed cropping systems in an intensive agricultural region of China

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Abstract

^{15}Nitrogen (N) tracer experiment in an intensive agricultural region of China (North China Plain) was conducted to investigate the grain yields, fertilizer N use efficiency (FNUE) and the fate of fertilizer N in the new designed cropping systems as compared with the conventional winter wheat-summer maize cropping system. We found that winter wheat-summer maize-spring maize and winter wheat-summer soybean-spring maize together with optimized N, water, straw and tillage management will deliver significant improvements in the environmental footprints and sustainability of intensively managed cropping systems in the North China Plain.

Keywords: nitrogen use efficiency, grain yield, new designed cropping systems, North China Plain

1. Introduction

The North China Plain (NCP) is the most productive cropland region in China. However, overuse of nitrogen (N) fertilizers and overexploitation of groundwater for irrigation have caused environmental degradation in the region. The objective of the present study was to investigate the grain yields, fertilizer N use efficiency (FNUE) and fate of applied fertilizer N in the new designed cropping systems as compared with the conventional winter wheat-summer maize cropping system.

2. Methods

The ^{15}N fertilizer microplots were set up in a long-term field experiment at Quzhou Experimental Station (36.87°N, 115.02°E), China Agricultural University.

The control treatment is the conventional winter wheat-summer maize cropping system in one year (Con. W/M), The other four cropping systems were designed with optimized management of N, water, straw and tillage, named new designed cropping systems, including optimized winter wheat-summer maize cropping system in one year (Opt. W/M); three harvests in two years, including winter wheat-summer maize-spring maize system (W/M-M) and winter wheat-summer soybean-spring maize (W/M-S); and one harvest in one year (spring maize, M).

3. Results

The results showed that only 18-20% of fertilizer N was recovered by crops in Con. W/M with high fertilizer N losses. Although the Opt. W/M significantly increased FNUE to 33-35% with increased crop yields, it still consumed as much groundwater as Con. W/M. The W/M-M, W/S-M and M significantly increased FNUE to 27-44% and reduced groundwater use and fertilizer N losses when compared to Con. W/M. The W/M-M achieved a comparable grain yield, but W/S-M and M had significantly lower grain yield when compared to Con. W/M. However, grain N harvest in W/S-M was comparable with Con. W/M due to higher grain N content in soybean. The residual fertilizer N in soil after harvest accounted for 54-69% of applied fertilizer N in Con. W/M, which was highly vulnerable to being moved out of the root zone as observed in the second crop. The new

designed cropping systems significantly reduced residual fertilizer N to 31-52%. When taking the second crop into account, Con. W/M recovered 27% of fertilizer N, while it increased to 36-50% under the new cropping systems.

4. Conclusions

We conclude that winter wheat-summer maize-spring maize and winter wheat-summer soybean-spring maize together with optimized N, water, straw and tillage management will deliver significant improvements in the environmental footprints and sustainability of intensively managed cropping systems in the North China Plain.