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SHORT COMMUNICATION

Stem perimeter, height and biomass of maize (*Zea mays* L.) grown under different N fertilization regimes in Beijing, China

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Abstract

In this study, nitrogen fertilizer was applied to corn (*Zea mays* L.) at conventional (excessive) and recommended levels, and the growth response was assessed by measuring plant height and stem perimeter. Corn plant maximum height was observed in recommended rates of N fertilizer treatment, and the height without N fertilizer was the same as that receiving excess N fertilizer. Stem perimeter was greatest in the treatment with recommended levels of N fertilizer, followed by the excess N fertilizer treatment. Greater increases in stem perimeter and plant height were observed after application of fertilizer at recommended rates, compared to control without N fertilizer and treatment with excessive N fertilizer, showing that application of N fertilizer at recommended rates results in better growth than that observed after application of fertilizer at excessive rates (*i.e.* those used in local farming practice). This study shows that soil testing to determine appropriate rates of fertilizer application can reduce fertilizer application rates by more than 50%, while retaining optimum growth in plant height and stem perimeter. Therefore, decreasing application of fertilizer is feasible to reduce environmental pollution and the cost of agriculture.

***Keywords**:* Soil test and recommended fertilizer; Plant height; stem perimeter; N fertilizer; Excessive N fertilization; *Zea mays* L.

Introduction

Nitrogen (N) fertilizer use has played a significant role in increase of crop yield (Modhej, et al., 2008). The application amounts of N fertilizer have dramatically increased in recent years, resulting in excessive use of N fertilizer in China (Ju et al., 2004), thus severe environmental and ecological problems, for example, nitrate pollution in groundwater (Peter et al., 2003), eutrophication of coastal waters (Hans, 2006) and greenhouse gas emissions that contribute to global warming (Clemens et al., 2008). In

2005, the Chinese Ministry of Agriculture initiated a program to address such problems. The Soil Test and Recommended Fertilizer Program received 900 million Yuan (equal to about 120 million dollar at this moment) in 2007, and will receive increasing funding over the coming years. The Soil Test and Recommended Fertilizer Program reduced N fertilizer application by more than 10–30%, while yield increased by 8–10%.

In assessing soil and recommended fertilizer levels, the study is largely on crop yield and amount of fertilizer use. Crop yield and chlorophyll concentration have been used to assess plant responses to N fertilizer (Tsialtas and Maslaris, 2008; Huang et al., 2008; Arregui et al., 2006). However, the effects of soil testing and recommended fertilizer levels on the development of corn have not been investigated. There is no information on the height and stem perimeter that determine light vertical distribution, biomass production and final yield. Based on previous research carried out using a solution culture system (Diao and Qian, 2008), it was thus important for us to investigate the effect of N supply on the height and stem perimeter in field conditions. In this paper, we examined the response of plant height and stem perimeter of corn grown to N fertilizer levels under field conditions.

Materials and Methods

The N fertilizer is in the form of $CO(NH_2)_2$ (total N is no less than 46.4%). P fertilizer is in the form of superphosphate, which contains no less than 16% P_2O_5. K fertilizer is in the form of KCl, which is red and contains no less than 60% K_2O. Zn fertilizer is in the form of $ZnSO_4$, which contains no less than 95% $ZnSO_4$.

A filed experiment was carried out at the Shangzhuang Experimental Station, China Agricultural University, Beijing (40°02' N, 116°20' E). The initial levels of soil, whose type is light loam, mineral N were 16 kg ha^{-1} in the 0–30 cm layer, 26 kg ha^{-1} in the 30–60 cm layer, and 20 kg ha^{-1} in the 60–90 cm layer. The initial levels of soil mineral P, K, and organic matter were 11.17 mg/kg, 74.58 mg/kg, and 10.88 mg/kg respectively. The pH was 8.13 (Hu et al., 2006). Maize variety was Denghai 3719. Seeds were sown on April 28, 2008 at a density of 100,000 ha^{-1}. Each treatment was repeated four times.

Fertilization scheme

In all four treatments, the applications of basic P fertilizer, basic K fertilizer, and micronutrient were 90 kg P_2O_5 ha^{-1} (superphosphate), 80 kg K_2O ha^{-1} (KCl), 15 kg Zn ha^{-1} ($ZnSO_4$). N fertilizer was applied at various rates as shown in Table 1.

Table 1. Application of Nitrogen Fertilizer in Different Stage.

Treatment	Basal fertilization	Elongation stage	Big-horn tasseling stage	Flowering stage	Milk stage	Total
CK	0	0	0	0		0
Farmer practice	175	50	170	55		450
Optimized	68	52	30	30	45	225

Treatment 1 (control, TR 1): No N fertilizer was used during the entire growth period of corn. This was designated as the zero control.

Treatment 2 (TR 2): The timing and application rate of N fertilizer were as normal farming practice in this region.

Treatment 3 (optimized treatment, TR 3): Optimized treatment, *i.e.* fertilizer was applied according to the needs of the plants to achieve the best ratio of yield to input. Quantity of N fertilizer was determined by measuring N min in the soil.

Water management

The rainfall during the germination period was sufficient for growth, thus additional irrigation was not used and the rainfall from April 20 to July 8 2008 is shown in Figure1.

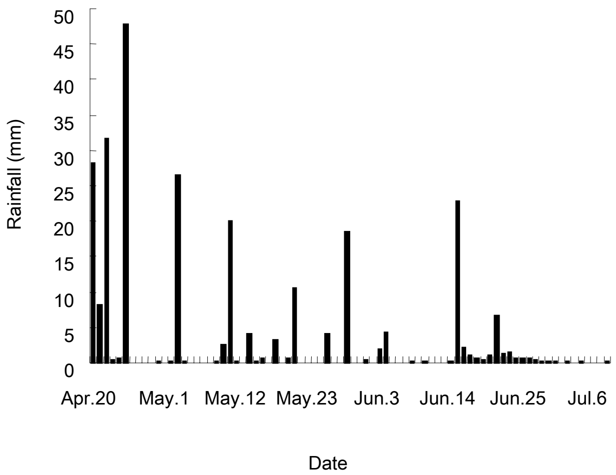

Figure 1. The rainfall from Apr. 20 2008 to Jul. 8 2008 at Shangzhuang experimental station of China Agricultural University.

Results

Plant height of corn at different stages is shown in Figure 2. In all treatments, the height of corn plants reached its maximum at same time (prior to the milk stage). The greatest height was achieved in the treatment in which fertilizer was applied according to demand (e.g. around 10 cm greater at final measurement). When N fertilizer was applied at the conventional application rate used by farmers in the region, the height of corn was not increased compared with that of the control. In this treatment N fertilizer application is in excess of the plants' demands.

The stem perimeter of corn at different stages is shown in Figure 3. Stem perimeter did not increase after June 24, indicating that stems finished expansion earlier in width than in length (plant height, Figure 2.). The stem perimeter increased after N application, but a greater increase in stem perimeter occurred after application of N fertilizer according to the plant demand, compared with the conventional levels used by local farmers (Figure 3).

Again, this suggests that the conventional levels of N fertilizer are excessive to plant growth demands.

Biological dry yield for different treatments is shown in Figure 4. The sampling date was Jul. 22. The lowest biomass production was in CK treatment (without N application) (Figure 4) which shows that N fertilizer is important for achieving ideal biomass yield. The biomass yield in optimized treatment is 11.7% higher than farmer practice treatment, showing that decreasing input of N fertilizer and increasing yield can be obtained at the same time.

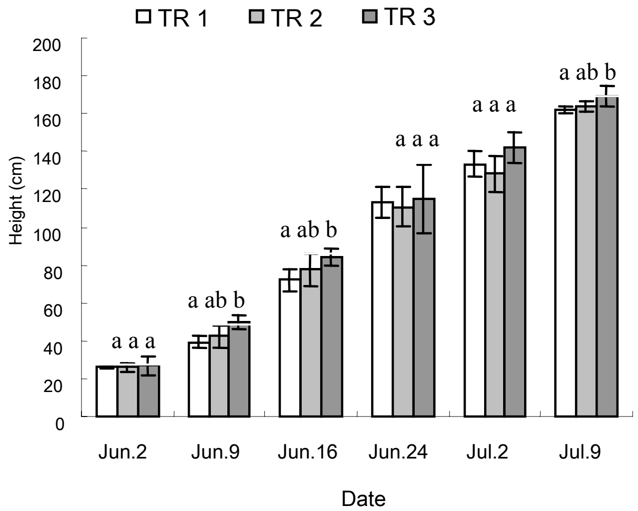

Figure 2. Effects of the different N treatments on the height of corn. Values represent means (n = 12 per treatment).

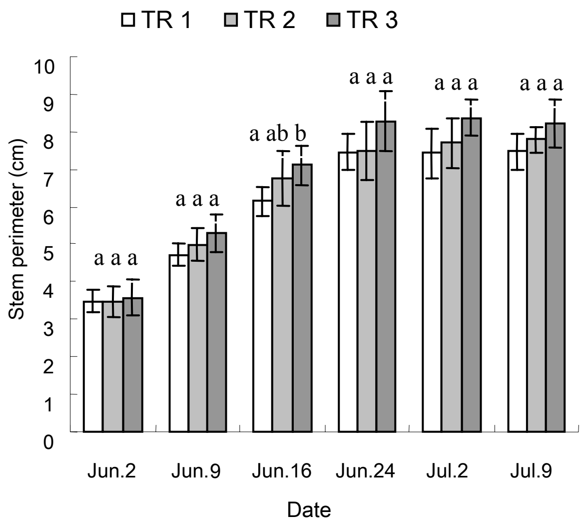

Figure 3. Effects of N treatments on stem perimeter of corn. Values represent means (n = 12 per treatment).

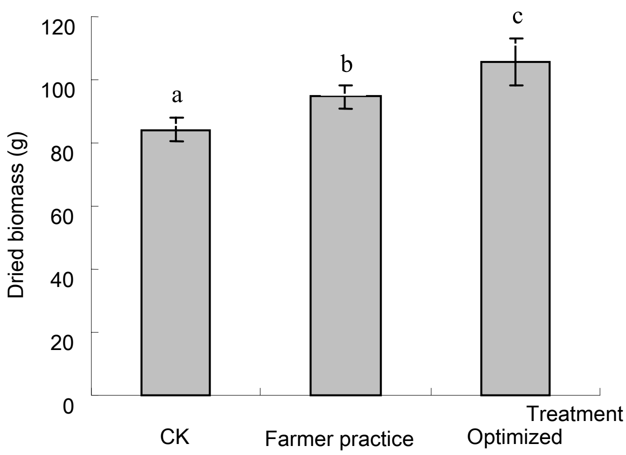

Figure 4. The dried biomass of different treatments on Jul. 22 (n=4).

Discussion

Our study confirms that application of N fertilizer can promote corn growth. It is well established that soil testing to determine the recommended fertilizer application rate results in increased corn yields and appropriate N input (Sun et al., 2008). It is also known that excessive N negatively affects the partitioning of plants' photosynthetic products (Draycott and Christenson, 2003). Our results show that plant height and stem perimeter are adversely affected by excessive application of N fertilizer, and that soil testing to determine recommended fertilizer application rate improves plant growth. Previous research has shown that excessive application of N fertilizer can inhibit root growth in corn (Wang et al., 2008). Roots are very important not only for absorbing water and nutrients, but also for optimizing plant growth by releasing substances such as organic acids (Renato and Paulo, 1997). We found that the greatest increases in height and stem perimeter of corn occurred, which completed the findings in both roots and shoots of plant growth when soil was tested and fertilizer was applied at an optimum rate in response to plants' demands. This result suggests that soil testing and application of appropriate levels of N fertilizer can help achieve efficient, high production in corn crops.

Conclusion

Soil testing and application of N fertilizer at recommended levels can reduce fertilizer application rate by 50%, while increasing plant height and stem perimeter of corn plants, and the total biomass increase by more than 10%. Therefore, this study provides additional evidence that reduced use of N fertilizer is feasible for reduction of environmental pollution and the cost of agricultural practice.

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