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Nutrient content in maize kernels grown on different types of soil

Contenido de nutrientes en mazorcas de maíz cultivado en diferentes tipos de suelo

Li SL, YB Zhang, YK Rui, XF Chen

Abstract. Minerals are essential for human nutrition and plant growth and development. Nutrient concentrations in plants are related to many factors, including soil types. The impact of soil types on nutrient accumulation in corn, grown in black and sandy soils, was studied in the same area and management conditions. The results showed that the descending order of nutrient content was Ca > Fe > Zn > Mn > Cu > Se > Mo in both soil types. The contents of Ca, Mn, Fe, Se and Mo in kernels of corn grown in sandy soil were higher than those in corn grown in black soil. On the other hand, the contents of Cu and Zn in kernels of corn grown in sandy soil were lower than those in corn grown in black soil, although differences were not significant ($p>0.05$).

Keywords: Soil type; Black soil; Sandy soil; Corn; Nutrients.

Resumen. Los minerales son esenciales para la nutrición humana y el crecimiento y desarrollo vegetal. La concentración de los nutrientes en las plantas está relacionada a varios factores, incluyendo el tipo de suelo. Se estudió el impacto del tipo de suelo en la acumulación de nutrientes en maíz que creció en suelos con alto contenido de materia orgánica o en suelos arenosos. Estos estudios se efectuaron en la misma área y bajo las mismas condiciones de manejo. Los resultados mostraron que el contenido en ambos tipos de suelo fue Ca > Fe > Zn > Mn > Cu > Se > Mo. Los contenidos de Ca, Mn, Fe, Se y Mo en mazorcas de maíz que creció en suelos arenosos fueron mayores que aquellos en maíz que creció en suelos con alto contenido de materia orgánica. Por otro lado, los contenidos de Cu y Zn en mazorcas de maíz que creció en suelos arenosos fueron menores que aquellos obtenidos en maíz que creció en suelos con alto contenido de materia orgánica, aunque las diferencias no fueron significativas ($p>0,05$).

Palabras clave: Tipo de suelo; Suelos con alto contenido de materia orgánica; Suelos arenosos; Maíz; Nutrientes.

College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193, China
Address Correspondence to: Rui Yukui, Yuanmingyuan Xilu No.2, Haidian District, Beijing city, China, College of Resources and Environmental Sciences, China Agricultural University, *e-mail:* ruiyukui@163.com
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INTRODUCTION

The so-called black soils are those with a content of organic matter that ranges from 3% to 10%, mainly distributed in China's Heilongjiang and Jilin provinces. Geological experts have pointed out that one centimeter thick formation of black soils takes 200 years to 400 years. The most prominent features of black soils are: (1) Black soils have a deep layer of black humus, which is usually 70 cm thick. (2) Black soils have a good soil structure; most of humus layer has a granular and group-like structure; water-stable aggregates range from 70 to 80%; porous. (3) Vertical profiles of black soils have no Calcium laminated or calcareous layer, but there are rust patterns, with iron-manganese nodules in its deposition layer (He et al., 2003).

Sandy soil is the initial stage of soil development, whose pedogenesis is weak. Sandy soil is composed by sand, where vegetation can be easily damaged. Vegetation on sandy soils is sparse. Sandy soils contain low organic matter content which ranges from 1 to 6 g/kg (Jiao, 2010).

Nutrient concentrations in plants are related to many factors, such as types of soil and many other biotic and abiotic characteristics (Zhao et al., 1998; Zhong et al., 2007; Zhang et al., 2010). In this paper, the impact of soil types on nutrient accumulation in corn grains was investigated at the same area and under the same management conditions.

MATERIALS AND METHODS

Field experiment. Cultivar: Xianyu 335. Density: 60000 plants/ha, Row spacing: 0.6 m; Seedling Distance: 0.28 m; Test plot area: 6 × 4 m = 24 m^2. Nitrogen fertilizer: 120 kg/ha = basal fertilizer 60 kg/ha + large trump bell 60 kg/ha; 76 kg P_2O_5/ha; 100 kg K_2O/ha. Experimental site: Fujiajie village of Sikeshu town, Lishu County, Jilin province of China. Treatments: Black soil and sandy soil. Both treatments were replicated three times. Soil types are shown in Figure 1.

Fig. 1. Sandy soil (left) and black soil (right).
Fig. 1. Suelo arenoso (izquierda) y suelo con alto contenido de materia orgánica (derecha).

Detection method. Sample pre-treatment: Add 8 mL nitrate and some PTFE in the 0.5 g sample; digest the sample using a microwave digestion device, cooling, constant volume to 25 mL for detection. Determination of the contents of Ca, Cu, Zn, Mn, Fe, Se and Mo: by ICP-MS.

The parameters of ICP-MS were referred to Rui's methods (Rui et al., 2006; Rui et al., 2009).

RESULTS AND DISCUSSION

Effects of soil type on maize yield. Yields of maize grown on black soil were similar (p>0.05) to those found when maize grew on sandy soil (Fig. 2).

Yields of maize after it was fertilized once or twice during two growing seasons were similar (p>0.05) in both soil types (data not shown). This indicates that soil type had no significant effects on corn yields. These results differ from those of Gao et al. (2007), who reported that after fertilizing maize either once of twice, yields were greater when maize grew on black than sandy soils.

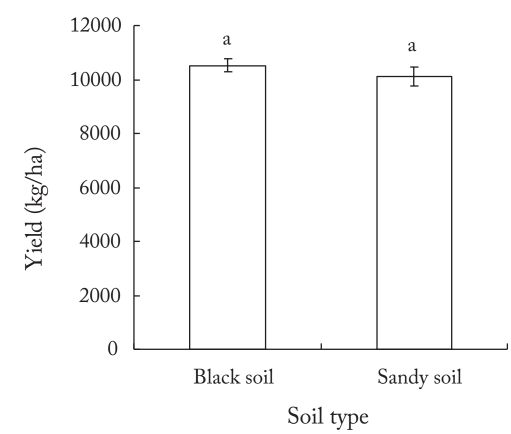

Fig. 2. Maize yield grown under different soil types.
Fig. 2. Rendimiento de maíz cultivado en diferentes tipos de suelo.

Nutrient content in maize grains. Nutrients are of great significance for plant growth and development, and an important indicator of the quality evaluation of corn. Ca can stabilize the biofilm structure and maintain cell integrity (Xu et al., 2004); Cu is ingredient of many oxidases in plants, and participates in many redox reactions, affects nitrogen metabolism, and promote the development of flower organs (Liu et al., 2007a); Zn affects plant carbon and nitrogen metabolism, participates in photosynthesis and auxin synthesis, and promote reproductive development and improve resistance (Liu et al., 2007b); Mn is ingredient of many enzymes (Wang et al., 2009); Fe is necessary for the composition of chlorophyll synthesis (Cui et al., 2010); Se has anti-aging effects (Liu et al., 2003) and Mo participates in the composition of nitrogenase and nitrate reductase (Liu et al., 2011).

Results showed that the order of content was Ca > Fe > Zn > Mn > Cu > Se > Mo in both soil types (Table 1). Contents of Ca, Mn, Fe, Se and Mo in corn kernel grown in sandy soil were higher than those in maize grown in black soil. Significant differences ($p<0.05$), however, were only found for Ca, Se and Mo. On the other hand, contents of Cu and Zn in corn kernel grown in sandy soil were lower than values found in black soil, but differences were not significant ($p>0.05$) (Table 1). Sandy soils contain enough Mn and Fe trace elements, which could be important to explain why maize grain grown in sandy soil contained more Fe and Mn than that grown in black soil (Li et al., 2005). Also, sandy soil has a good permeability, where maize has well-developed root hairs and a strong absorption capacity of trace elements (Fan & Yang, 2009); this could also help to explain why maize grain grown in sandy soil contained more trace elements.

Table 1. Nutrient content in maize grown under different soil types.
Tabla 1. Contenido de nutrientes en maíz cultivado en diferentes tipos de suelo.

Elements	Black soil	Sandy soil
Ca	29.45 ± 1.21μg/g	36.36 ± 1.84μg/g
Cu	1.06 ± 0.07μg/g	0.97 ± 0.01μg/g
Zn	12.62 ± 0.41μg/g	11.74 ± 0.34μg/g
Mn	4.91 ± 0.31μg/g	5.8 ± 0.24μg/g
Fe	13.74 ± 0.78μg/g	14.78 ± 0.12μg/g
Se	33.76 ± 14.97ng/g	65.8 ± 2.40 ng/g
Mo	17.73 ± 5.70 ng/g	49.18 ± 3.91 ng/g

CONCLUSIONS

Soil type showed a significant impact on the nutrient content in maize, especially Ca, Se and Mo. However, soil type was not an important factor affecting maize yield under appropriate field management.

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