Nutrient Uptake of Maize Plants (*Zea mays* L.) in Relation to Zinc Deficiency

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Abstract

A three year field experiment using zinc sulfate supplements was conducted in Moldova to study nutrient uptake of maize plants in years 13 through 15 of systematic application of mineral fertilizers (no-fertilizer control, P60, N60K60, N60P60K60, N90P60K60, N60P90K60, kg ha^{-1}). Zinc treatments for three years were P60Zn10, N60P60K60Zn5, N90P60K60Zn5 and N60P90K60Zn10 on half of each long-term treatment. The objective of this study was to determine the macronutrient uptake of maize plants in relation to zinc deficiency and plant chlorosis. The soil at the experiment site was a calcareous chernozem, containing: humus 4.3%, total nitrogen 0.29%, $CaCO_3$ 1.7%, plant available phosphorus and potassium averaging 0.88 and 34.5 mg/100g respectively, extractable cations Ca^{2+} and Mg^{2+} 31 and 2.9 meq/100g respectively, with pH_{H2O} value of 7.9 at the 0-20 cm soil depth. Long term phosphorus application increased available phosphorus, induced zinc deficiency and decreased nutrient uptakes by maize. Measured in maize at milk-dough stage of maturity, the combined application of macro and microelements (N60P90K60 and N60P90K60Zn10) increased: the total nitrogen uptake in leaves by 159 mg plant-1 dry weight, in stem by 142, in husk by 171, in cob by 100, in grain 1094; total phosphorus uptake in leaves increased by 52, in stem by 68, in husk 78, in cob by 49, and in grain by 387; total potassium uptake in leaves increased by 73, in stem by 148, in husk by 175, in cob by 172, and in grain by 317. Maize yield was increased from 470 to 660 kg ha^{-1}. The total nitrogen, phosphorus and potassium uptake in tassel increased slightly. The results can be helpful in developing maize nutrient management on carbonate chernozem soil in dryland cropping system. *The results were obtained in Moldavian Scientific-Research Institute of Soil Science and Agricultural Chemistry, Chisinau, Moldova.

Introduction

In the field experiment with maize (*Zea mays* L.) zinc deficiency was observed with systematic, repeated phosphorus fertilizer applications to carbonate chernozem soil, causing plant chlorosis and necrosis. This field experiment was conducted to evaluate the effects of different zinc rates applied in combination with macroelements on nitrogen, phosphorus and potassium uptake of plant tissue during maturity of maize. Evaluation of nutrient uptake and partitioning provide the new knowledge for macro-and micronutrient management to achieve maze's maximum grain productivity in maize. However, there is little information on maize nutrient uptake and partitioning as function of combined application macro-and microelements to carbonate chernozem. Therefore, the objective of this study was to determine maize macroelements uptake as influenced by macro-and microelements fertilizers applied to carbonate chernozem.

Materials and methods

The field experiment was conducted at the Moldavian Scientific-Research Institute of Soil Science and Agricultural Chemistry's Central Agricultural Research Station. The soil at the experiment site was a calcareous chernozem, containing: humus 4.3%, total nitrogen 0.29%, $CaCO_3$ 1.7%, plant available phosphorus and potassium averaging 0.88 and 34.5 mg/100g respectively, extractable cations Ca^{2+} and Mg^{2+} were 31 and 2.9 meq/100g respectively, with pH_{H2O} value of 7.9 at the 0-20 cm soil depth. Maize hybrid 'Chisinau 167' was used as planting material. Nitrogen and phosphorus rates were 60 to 90, potassium 60 and zinc 5 to 10 kg ha^{-1}. Leaves, stem, tassel, husk, cob and grain were separated from randomly selected plants, weighed, dried, and ground for chemical nutrient analysis. Nitrogen concentration were determined by Kjeldahl, analysis phosphorus by colorimetry and potassium by flame photometry (Mineev, 1989). The experiment was laid out in a completely randomized design with four replications. Grain from each plot was hand-harvested and weighed.

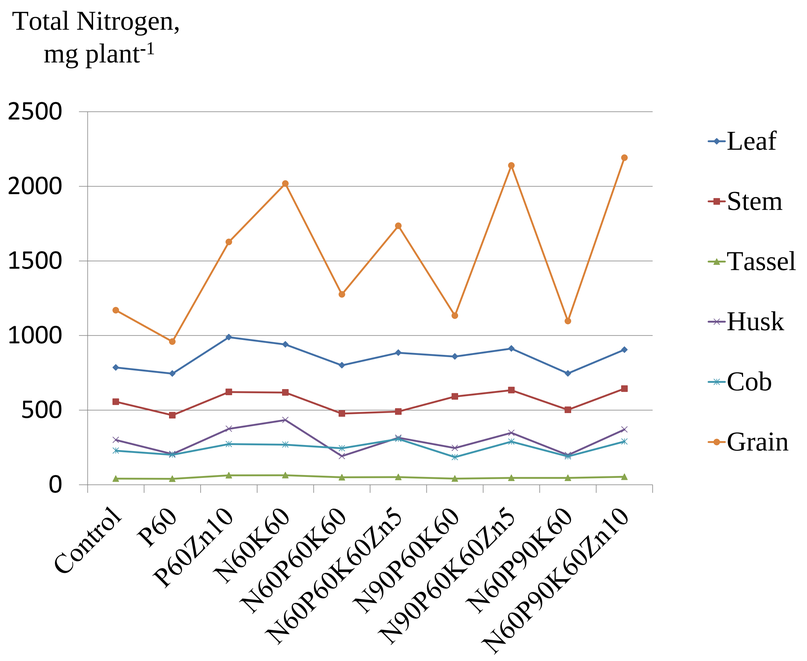

Fig. 1. Total nitrogen uptake and partitioning using various macro- and microelement treatments at milk-dough stage maize maturity

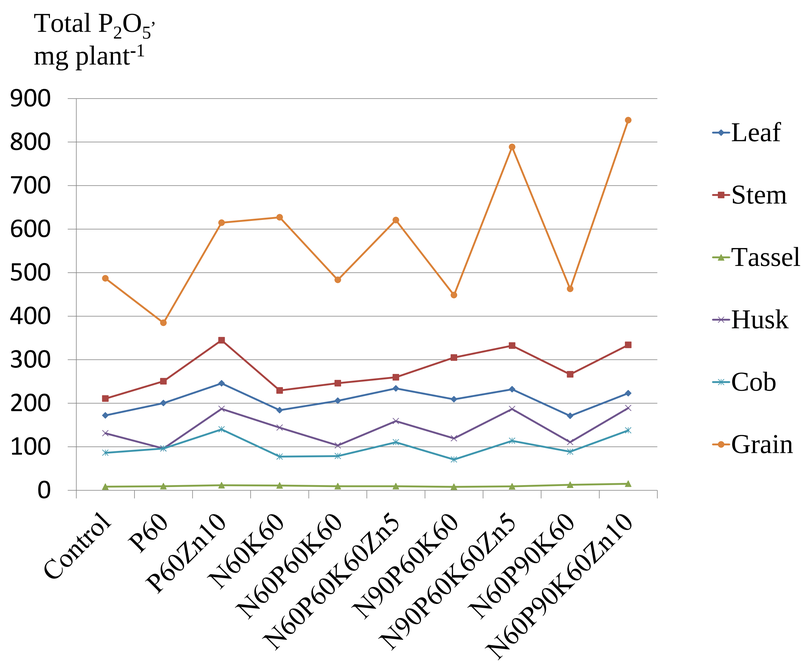

Fig. 2. Total phosphorus uptake and partitioning using various macro- and microelements treatments at milk-dough stage maize maturity

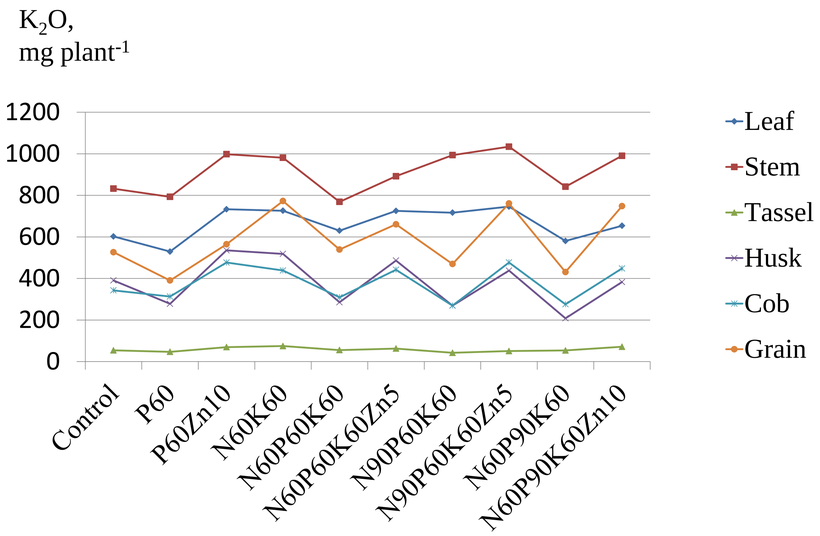

Fig. 3. Potassium uptake and partitioning using various macro- and microelements treatments at milk-dough stage maize maturity

Results and Discussion

Measured in maize at milk-dough stage of maturity, the combined application of macro and microelements (N60P90K60 and N60P90K60Zn10) increased: the total nitrogen uptake in leaves by 159 mg $plant^{-1}$ dry weight, in stem by 142, in husk by 171, in cob by 100, in grain by 1094; total phosphorus uptake in leaves increased by 52, in stem by 68, in husk 78, in cob by 49, and in grain by 387; total potassium uptake in leaves increased by 73, in stem by 148, in husk by 175, in cob by 172, and in grain by 317 (Fig. 1, 2, 3). The total nitrogen, phosphorus and potassium uptake in tassel increased slightly. Increasing either nitrogen or phosphorus rate from 60 to 90 kg ha^{-1} did not increased nutrients uptake by maize plants, whereas combined application of macro-and microelements increased nitrogen, phosphorus and potassium uptake by maize plants. The data presented in Fig. 1 and 2 indicate that nitrogen and phosphorus concentrated in maize grain and total nitrogen and phosphorus uptake have increased by almost twice when plants were fertilized by combined application of phosphorus and zinc fertilizers. Maize yield was increased from 470 to 660 kg ha^{-1}. The soil test results in 0-20 cm revealed that zinc deficiency stress of field maize related to values of phosphorus/zinc ration, which decreased from 95.1-104.3 to 26.2-32.3 after zinc sulfate fertilizer application. Therefore, systematic, repeated application of phosphorus fertilizers to carbonate chernozem requires soil test on available zinc in soil. The data can be helpful in developing micronutrient management strategy for maize production on carbonate chernozem soil in dryland cropping system.

Conclusion

The systematic, repeated application of phosphorus fertilizers to carbonate chernozem, led to maize zinc deficiency in maize. Zinc sulfate fertilizers application increased plant growth and development. The combined application of macro and microelements increased: the total nitrogen, phosphorus and potassium uptake by maize plants and consequently, the maize grain yield on carbonate chernozem soil. Hence, the use of zinc sulfate following systematic, repeated application of phosphorus fertilizers to carbonate chernozem soil is important to increase maize productivity in dryland cropping system.

Literature Cited

1. Mineev V. G., 1989. Methods of Agricultural Chemistry. Moscow State University Press.

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