Chemical Composition of Corn Sap As Influenced by Mineral Fertilizers Applied to Carbonate Chernozem Soil

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Abstract

A field experiment was conducted in Moldova to evaluate the effect of zinc sulfate on the chemical composition of corn sap following systematic application of mineral fertilizers to carbonate chernozem soil. Long term phosphorus application induced zinc deficiency in corn, which affected the development of the leaves and was manifested as plant chlorosis. The combined application of zinc sulfate, nitrogen, phosphorus, and potassium restored plant growth and development, increased plant biomass, and positively affected the chemical composition of corn sap. A positive response was observed between zinc sulfate application rates containing macro elements and the measured corn sap volume, which increased by 88 % (N60P90K60Zn10) at the 8-10 leaves plant stage compared to without zinc application (N60P90K60). Zinc sulfate decreased the concentration of nitrate nitrogen (NO3-N) from 147.7 (N60P90K60) to 126.3 mg/L (N60P90K60Zn10) and increased the ammonium nitrogen (NH4-N) from 25.3 to 36.9 mg/L in corn sap at the 8-10 leaves stage. Translocations of NH4-N and NO3-N in the corn sap from the root system to the upper stalk and leaves were 2.8 and 1.6 times higher, respectively, in plants receiving zinc fertilization at that stage. Free amino acids (lysine, histidine, arginine, serine, glycine, alanine, valine, isoleucine, tyrosine, and phenylalanine) concentrations in corn sap following combined phosphorus and zinc applications (P60Zn10) were at the same level as in the control. However, free amino acid levels in corn sap at the 8-10 leaves stage were higher following both phosphorus and zinc applications compared to applications of phosphorus only without zinc (P60). Zinc sulfate decreased inorganic phosphorus from 188 (N60P90K60) to 143.7 mg/L (N60P90K60Zn10) and increased organic phosphorus from 57 to 80.7 mg/L sap at 8-10 leaves stage. Translocation of inorganic and organic phosphorus from roots to above-ground corn plants was 1.5 and 2.8 times higher in zinc fertilized plants at the 8-10 leaves stage. There was not a large difference in potassium concentrations in corn sap, however, its translocation from the root system to upper parts of the plants was 1.8 times higher with zinc fertilization at that stage. Hence, in a phosphorus induced zinc deficient environment, zinc promotes nutrient uptake and increases biosynthetic processes in the corn root system.

Introduction

One of the key factors to enhance sustainable corn (*Zea mays* L.) production on carbonate chernozem soil is improving mineral nutrition. Long term phosphorus application induced zinc deficiency in corn, which affected plant growth, and was manifested as plant chlorosis. The combined application of zinc sulfate, nitrogen, phosphorus, and potassium restored plant growth and development, and positively affected the chemical composition of corn sap. The objective of this study was to evaluate the chemical composition of corn sap as affected by macro and microelements applied to carbonate chernozem.

Materials and Methods

A field experiment was conducted on carbonate chernozem soil for three years in Moldova. The soil is carbonate chernozem. The main soil physical and chemical properties of the 0-to 20 cm soil depths were: physical clay 60 %, soil organic matter 4.3 %, total nitrogen 0.29 %, carbonates 1.7 %, soil pH 7.9 and extractable P and Zn were 8.8, 0.35 mg kg^{-1}, respectively. Phosphorus and zinc were applied at three rates 0, 60, 90 and 0, 5, 10 kg ha^{-1} , respectively. Corn sap samples were collected from each plot during 24 hours at 5-6 and 8-10 leaves stages and were calorimetrically analyzed for NO3-N, NH4-N, and P2O5.

Results and Discussion

Zinc sulfate application containing macro elements, restored plant growth and development, increased corn sap volume at the 5-6 and 8-10 leaves plant stages by 1.66 and 1.88 (N60P90K60Zn10) times, respectively, compared to without zinc application (N60P90K60). Zinc sulfate decreased the concentration of nitrate nitrogen (NO3-N) from 147,7 (N60P90K60) to 126.3 mg/L (N60P90K60Zn10), inorganic phosphorus from 188 (N60P90K60) to 143.7 mg/L (N60P90K60Zn10) and increased the ammonium nitrogen (NH4-N) from 25.3 to 36.9 mg/L, and organic phosphorus from 57 to 80.7 mg/L in corn sap at the 8-10 leaves stage. Translocation of NH4-N, NO3-N, inorganic, organic phosphorus, and potassium in the corn sap from the root system to the upper stalk and leaves were greater in plants receiving zinc fertilization at that stage. These results indicate that the microelement zinc affected nutrients uptake and intensity of their translocation from the corn root system to the upper stalk and leaves.

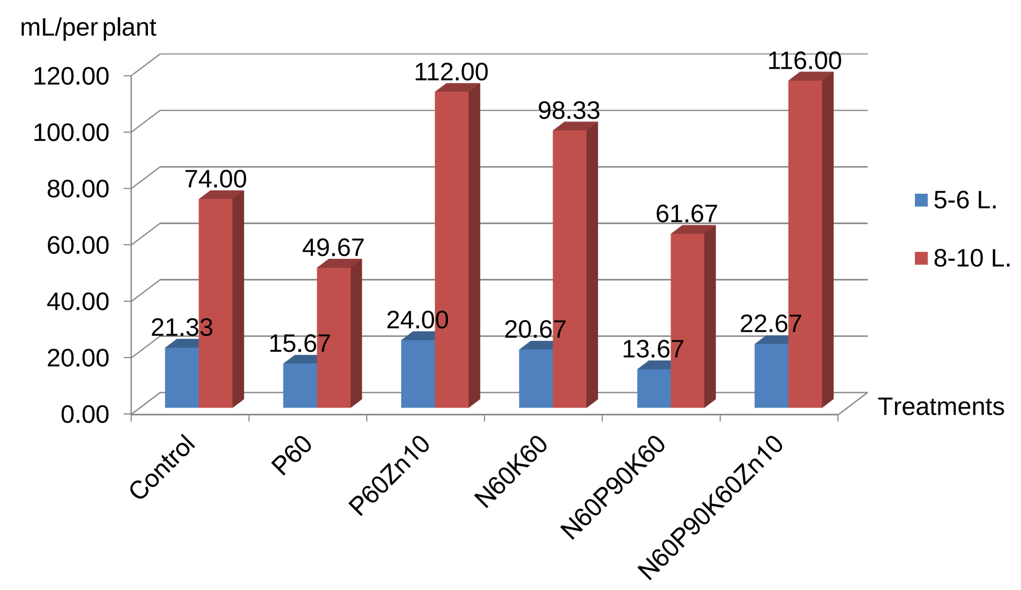

Fig. 1. Corn sap volume at the 5-6 and 8-10 leaves plant stages during 24 hours

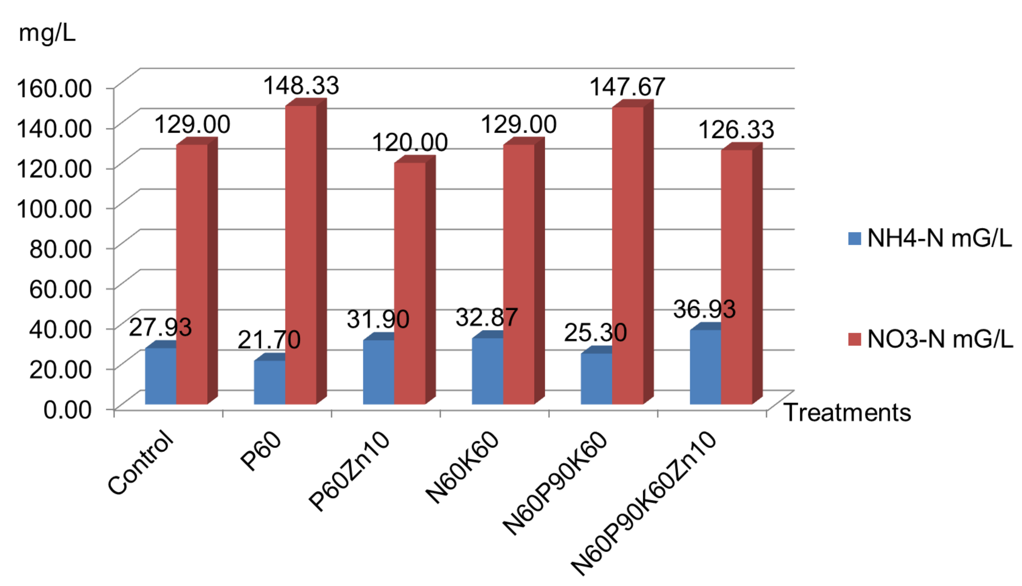

Fig. 2. Concentrations of ammonium nitrogen and nitrate nitrogen in corn sap at the 8-10 leaves stage

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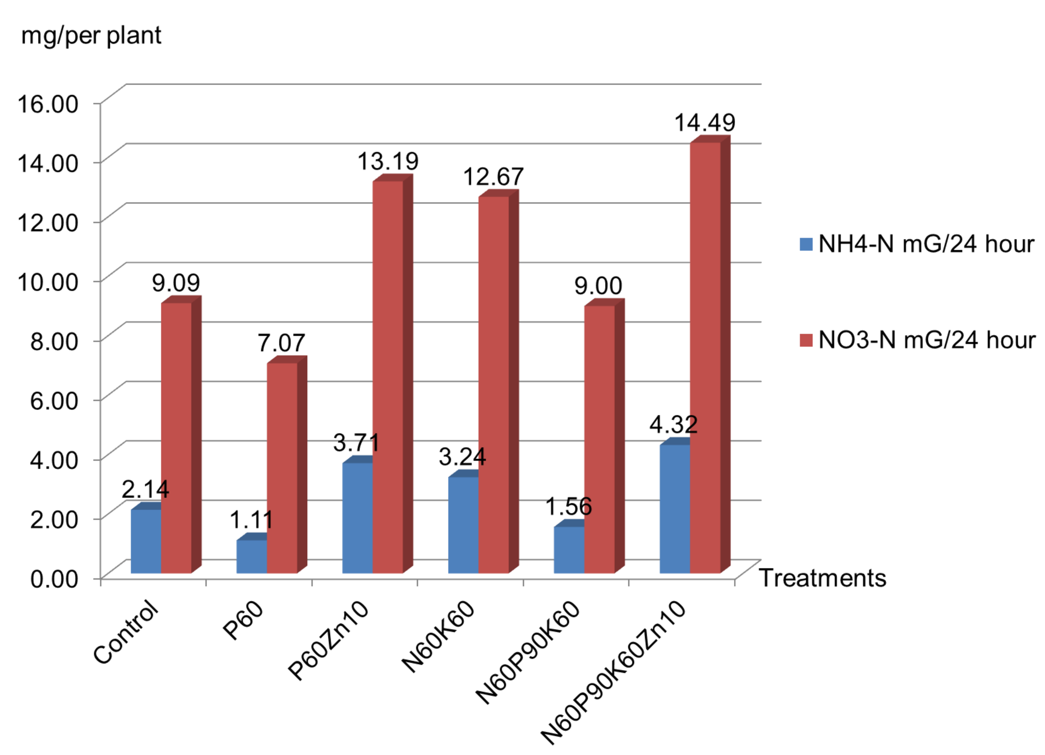

Fig. 3. Translocations of NH4-N and NO3-N in the corn sap from root system to the upper stalk and leaves at the 8-10 leaves stage

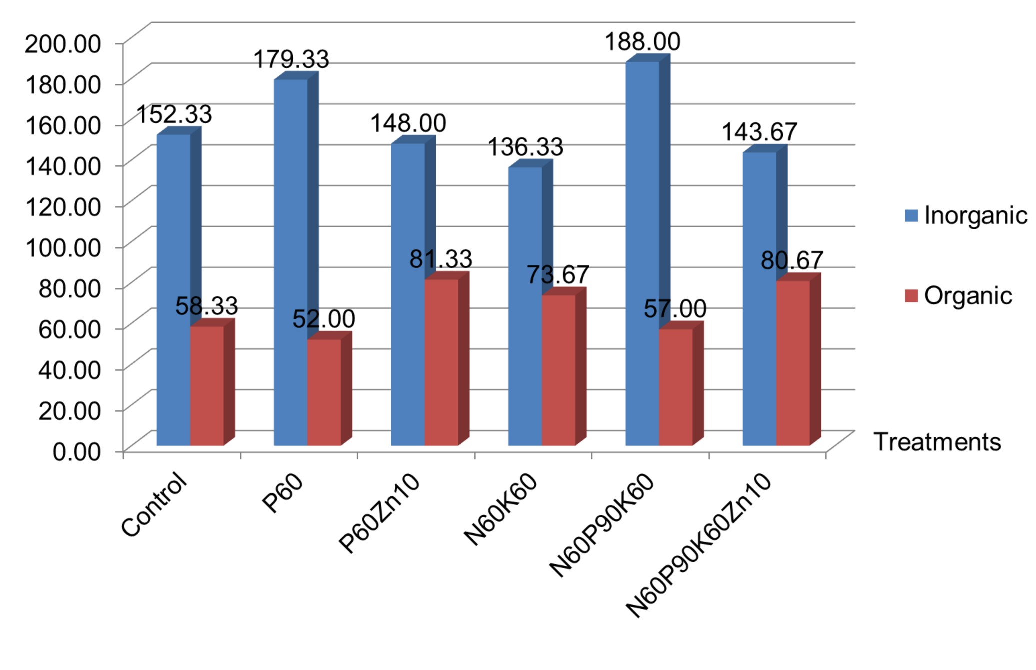

Fig. 4. Concentrations of inorganic and organic phosphorus in sap of corn at the 8-10 leaves stage

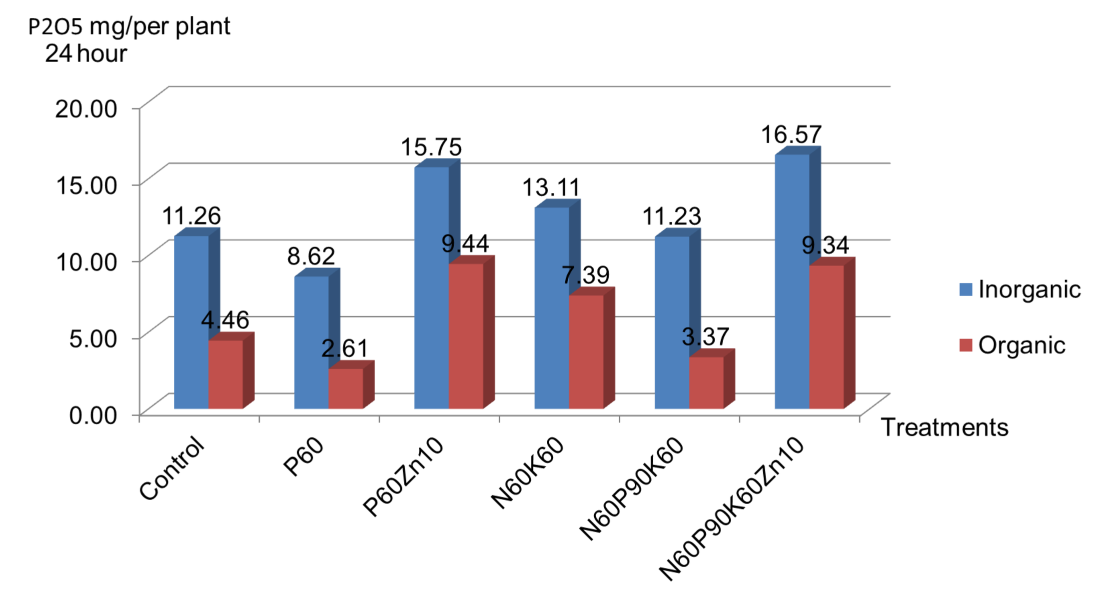

Fig. 5. Translocation P2O5 in the corn sap from root system to upper stalk and leaves at the 8-10 leaves stage

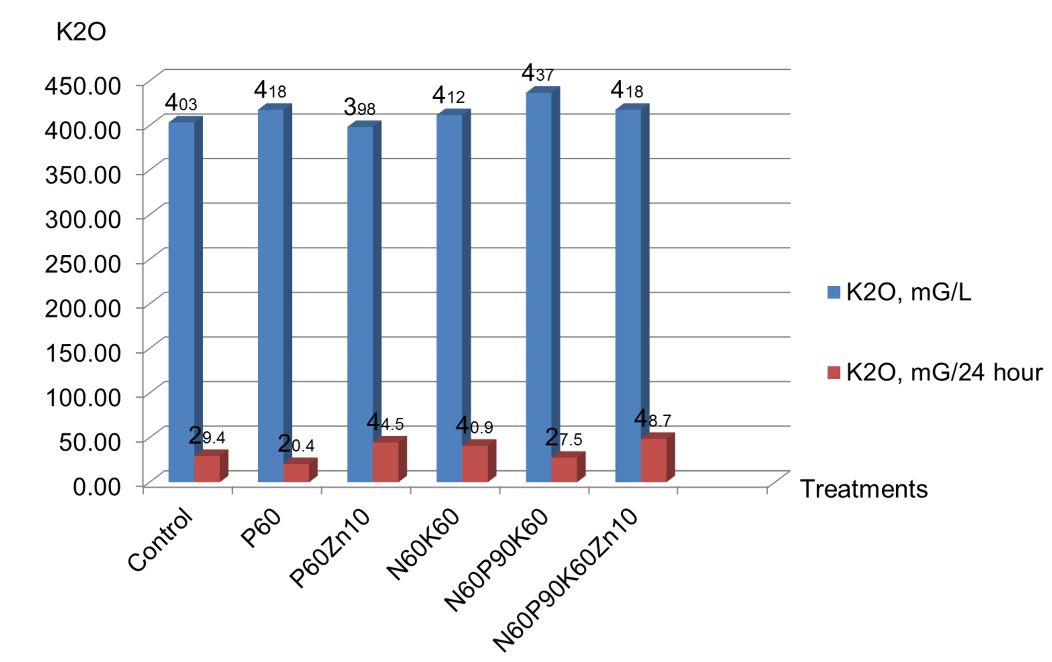

Fig. 6. Concentration and translocation of K2O in the corn sap from the root system to the upper stalk and leaves at the 8-10 leaves stage

Conclusions

Long term phosphorus application induced zinc deficiency in corn on carbonate chernozem soil. Zinc deficiency affected plant growth and was manifested as plant chlorosis. Applied zinc increased ammonium nitrogen and organic phosphorus in the corn sap, biosynthetic processes in the corn root system, promoted nutrient uptake, and restored plant growth and development.

Acknowledgments

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