Phosphorus Fractions in Maize (*Zea mays* L.) Plants as Affected by Phosphorus and Zinc Sulfate Application

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Abstract

Long-term phosphorus application on carbonate chernozem soil in legumes-winter wheat-maize-sunflower cropping system induced zinc deficiency in maize (*Zea mays* L.). Plants exhibited chlorosis, stunted growth due to shortening of stem internodes and decreased in leaf area. A field experiment with zinc sulfate supplements was conducted to study phosphorus fractions in maize plants during years 13 through 15 of systematic application of mineral fertilizers (No fertilizer control, P60, N60K60, N60P60K60, N90P60K60 and N60P90K60) to carbonate chernozem soil. Zinc treatments for three years were P60Zn10, N60P60K60Zn5, N90P60K60Zn5 and N60P90K60Zn10 on half of each long term treatment. The soil at the experiment site was a chernozem, containing: humus 4.3%, total nitrogen 0.29%, CaCO3 1.7%, plant available phosphorus and potassium averaging 0.88 and 34.5 mg/100 g 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. The results revealed that the zinc deficiency plants led to higher concentration of inorganic phosphorus in leaves and stems of maize, whereas concentration of sugar phosphorus + phytin, nucleoproteins, and phosphatides phosphorus were not largely changed at the 8-10 leaf stage. However, zinc treatment increased accumulation of inorganic phosphorus averaging from 36.2 to 60.6, as well as sugar phosphates + phytin from 11.8 to 40.4, nucleoproteins from 8.2 to 28.6 and phosphatides phosphorus from 4.9 to 15.3 mg $plant^{-1}$ in leaves and inorganic phosphorus from 24.2 to 50.6, sugar phosphates + phytin from 7.6 to 37, nucleoproteins from 6.6 to 30.5 and phosphatides phosphorus from 3.1 to 13.1 mg plant-1 dry weight in stems at the 8-10 leaf stage compared to no zinc application (P60, P60Zn10). The observed accumulation of phosphorus fractions in leaves and stems related to the higher zinc accumulation in maize leaves. High positive linear correlations were observed between total zinc content in leaves and accumulation of organic form of phosphorus fractions in leaves of maize. Hence, maize grown on carbonate chernozem under long term phosphorus application increased the demand for zinc fertilization. Therefore, combined application of macro - and microelements to carbonate chernozem is important to improve maize phosphorus metabolism. *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. A field experiment with zinc sulfate supplements was conducted to study phosphorus fractions in maize plants during years 13 through 15 of systematic application of mineral fertilizers. Evaluation of phosphorus metabolism provide new knowledge for macro- and microelement management to achieve maximum maize grain yield. However, there is little information on maize phosphorus fractions content in leaves and stems as function of prolonged combined application macro- and microelements to carbonate chernozem soil. Therefore, the objective of this study was to determine maize phosphorus fractions content in leaves and stems as function of macro -and microelements fertilizers applied to carbonate chernozem soil.

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}. Phosphorus fractions concentrations in fresh leaves and stems were determined by colorimetric method. The experiment was laid out in a completely randomized design with four replications.

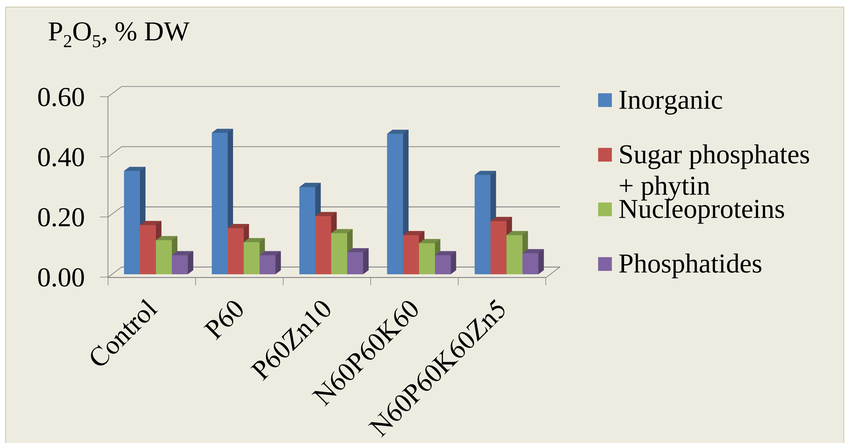

Fig. 1. Concentration of phosphorus fractions in leaves of maize at the 8-10 leaf stage

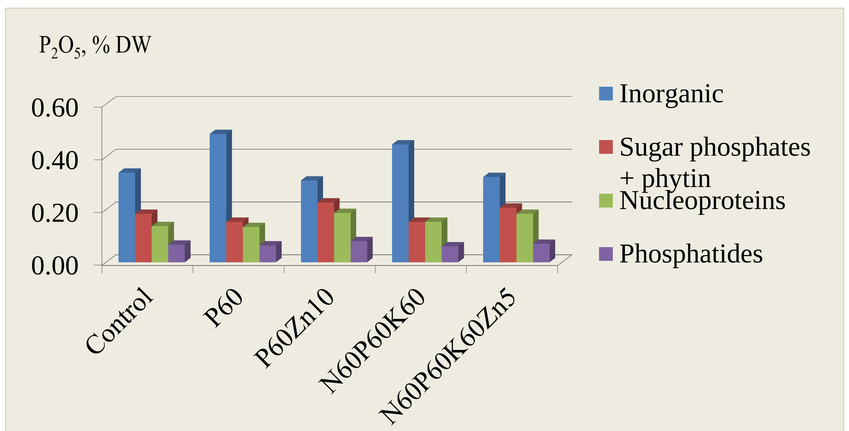

Fig. 2. Concentration of phosphorus fractions in stems of maize at the 8-10 leaf stage

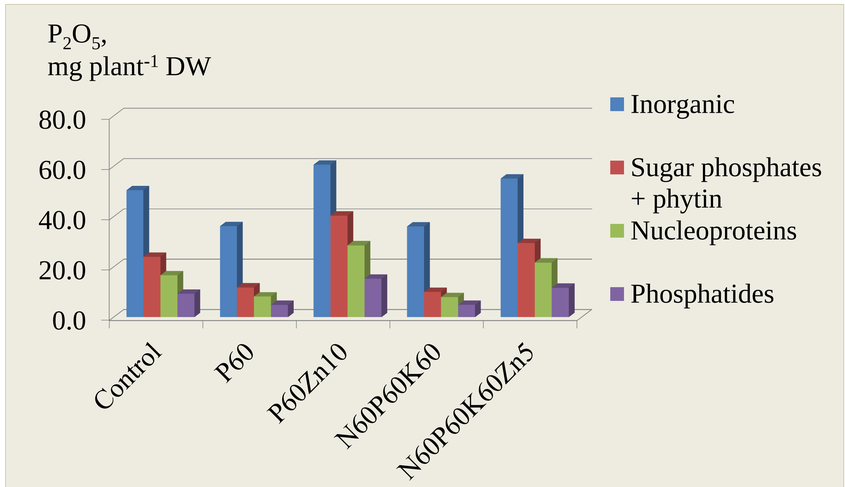

Fig. 3. Total phosphorus fractions in leaves of maize at the 8-10 leaf stage

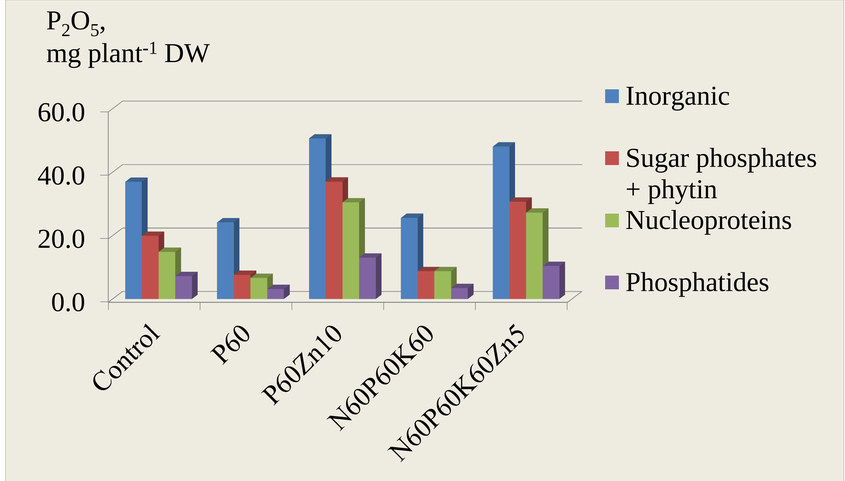

Fig. 4. Total phosphorus fractions in stems of maize at the 8-10 leaf stage

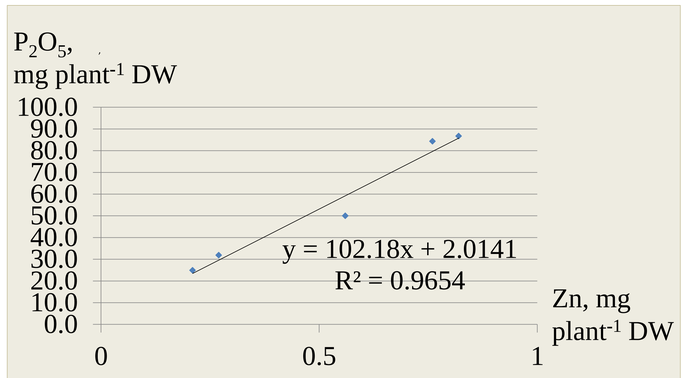

Fig. 5. Positive linear correlations between total organic phosphorus fraction and zinc content in leaves of maize at the 8-10 leaf stage (Control, P60, N60P90K60, P60, P60Zn10 and N60P90K60Zn10).

Results and discussion

The results revealed (Fig. 1, 2, 3, 4) that the zinc deficiency led to higher concentration of inorganic phosphorus in leaves and stems of maize, whereas concentration of sugar phosphorus + phytin, nucleoproteins, and phosphatides phosphorus were not largely changed at the 8-10 leaf stage. However, zinc treatment increased accumulation of inorganic phosphorus averaging from 36.2 to 60.6, as well as sugar phosphates + phytin from 11.8 to 40.4, nucleoproteins from 8.2 to 28.6 and phosphatides phosphorus from 4.9 to 15.3 mg $plant^{-1}$ in leaves and inorganic phosphorus from 24.2 to 50.6, sugar phosphates + phytin from 7.6 to 37, nucleoproteins from 6.6 to 30.5 and phosphatides phosphorus from 3.1 to 13.1 mg $plant^{-1}$ dry weight in stems at the 8-10 leaf stage compared to no zinc application (P60, P60Zn10). Positive linear correlations (Fig. 5) was observed between zinc content in leaves and total organic phosphorus accumulation in leaves of maize at the 8-10 leaf stage.

Conclusion

Zinc deficiency in plants led to higher concentration of inorganic phosphorus in leaves and stems of maize, whereas concentration of sugar phosphorus + phytin, nucleoproteins, and phosphatides phosphorus were not largely changed at the 8-10 leaf stage. However, zinc treatment increased accumulation of inorganic phosphorus, as well as sugar phosphates + phytin, nucleoproteins, and phosphatides phosphorus in leaves and stems at the 8-10 leaves stage compared to no zinc application (P60, P60Zn10). Hence, the use of zinc sulfate following prolonged application of phosphorus fertilizers to carbonate chernozem soil is important to improve maize phosphorus metabolism.

Acknowledgements

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