Maize (*Zea mays* L.) Monosaccharides Content as Affected by Zinc Sulfate Following Systematic Application of Mineral Fertilizers to Carbonate Chernozem

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Abstract

A three year field* experiment with zinc sulfate supplements was conducted in Moldova to study maize (*Zea Mays* L.) monosaccharides contents in years 13 through 15 years of systematic application of mineral fertilizers (no-fertilizer control, P60, N60K60, N60P60K60, N90P60K60, N60P90K60 kg ha^{-1}) to carbonate chernozem. Zinc treatments for 3 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. Long term phosphorus application induced zinc deficiency and decreased synthesis of carbohydrates and chlorophyll in maize. Zinc treatments compared to no zinc application significantly increased total monosaccharides in leaves (dry weight ranges 1.63-1.93% vs. 0.93-0.97%) and in stems (range 12.2-14.17% vs. 6.93-7.07% of at the 5-6 leaves stage. Chlorophyll concentrations (fresh weight ranges 14.07-17.73 mg% vs. 6.6-10.3 mg%) were significantly higher in plants supplied with zinc than those without zinc. Overall, zinc significantly increased leaf area 17.07 to 84.33 dm^2 per plant. Significant positive correlations were observed between monosaccharides in leaves or stems and chlorophyll content (r=.67 and r=.70 respectively), as well as between monosaccharides in leaves or stems and leaf area values (r=0.73 and r=.83). Hence, the use of zinc sulfate following systematic repeated application of phosphorous fertilizers to carbonate chernozem is essential to improving maize carbohydrates metabolism. *The results were obtained in Moldavian Scientific-Research Institute of Soil Science and Agricultural Chemistry, Chisinau, Moldova.

Introduction

Micronutrient zinc is important in corn carbohydrate metabolism and its deficiency affects the plant growth and development. In the field experiment, corn (*Zea mays* L.) zinc deficiency was observed with long term phosphorus fertilizer applications to carbonate chernozem, which led to plant interveinal chlorosis and necrosis. One of the key factors to increase corn carbohydrates is improving macro-and microelements nutrition. In the greenhouse experiment corn zinc deficiency was observed at high phosphorus and low zinc level (Warnock, 1970). However, there is little information on corn carbohydrates content as function of combined application macro-and microelements to carbonate chernozem. Therefore, the objective of this study was to determine corn total monosaccharides content as influenced by macro-and microelements applied to carbonate chernozem.

Materials and Methods

Field experiment was conducted at the Central Agricultural Research Station of the Moldavian Scientific-Research Institute for Soil Science and Agricultural Chemistry, where precipitation during research ranged from 282 to 518 mm annually. The soil at the experimental field was a carbonate 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/100 g respectively, with pH_{H2O} value of 7.9 at the 0-20 cm soil depth. Corn hybrid 'Chisinau 167' was used as planting material. Colorimetric method was used to determine the total chlorophyll content and a chemical method (Pleshkov, 1976) to determine monosaccharides content in corn samples. The experiment was laid out in a completely randomized design with four replications. Analyses of variance of the data were carried out using SAS (version 9.2; SAS Institute, Cary, NC, USA).

Results and Discussion

The results (Fig. 1, 2) revealed that zinc treatments compared to no zinc application significantly increased total monosaccharides in leaves (dry weight ranges 1.63-1.93% vs. 0.93-0.97%) and in stems (range 12.2-14.17% vs. 6.93-7.07% of at the 5-6 leaves stage. Chlorophyll concentrations (fresh weight ranges 14.07-17.73 mg% vs. 6.6-10.3 mg%) were significantly higher in plants supplied with zinc than those without zinc. Overall, zinc significantly increased leaf area 17.07 to 84.33 dm^2 per plant. Significant positive correlations were observed between monosaccharides in leaves or stems and chlorophyll content (r=.67 and r=.70 respectively), as well as

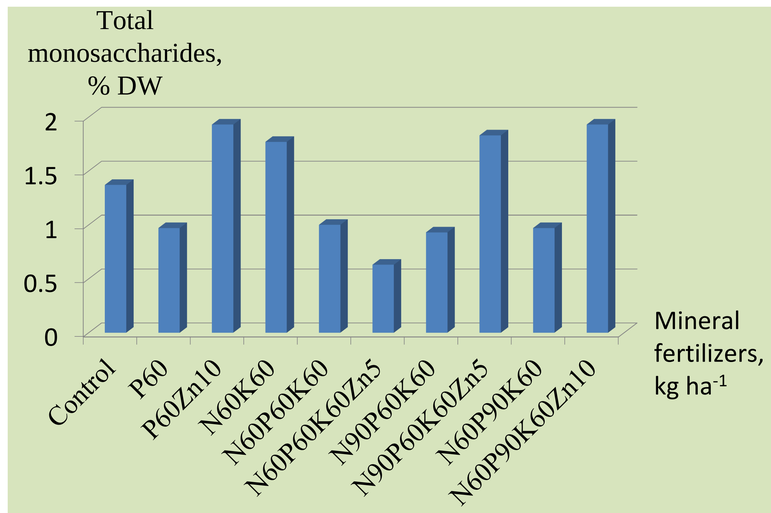

Fig. 1. Leaves' monosaccharides response to macro-and microelements at the 5-6 leaves stage

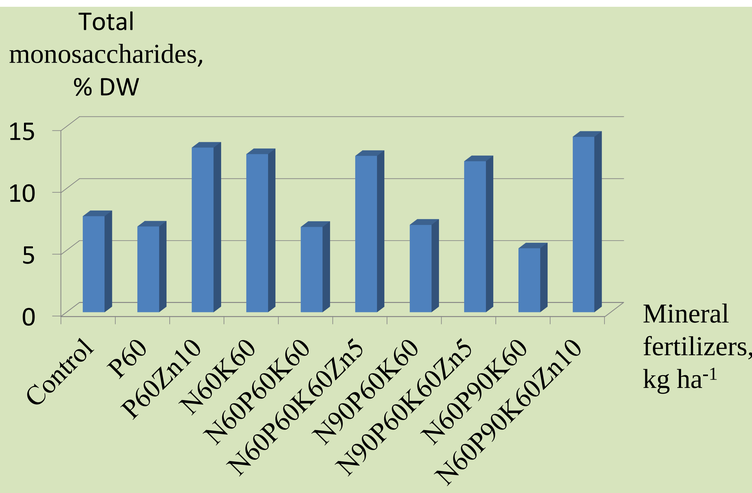

Fig. 2. Stem's monosaccharides response to macro-and microelements at the 5-6 leaves stage

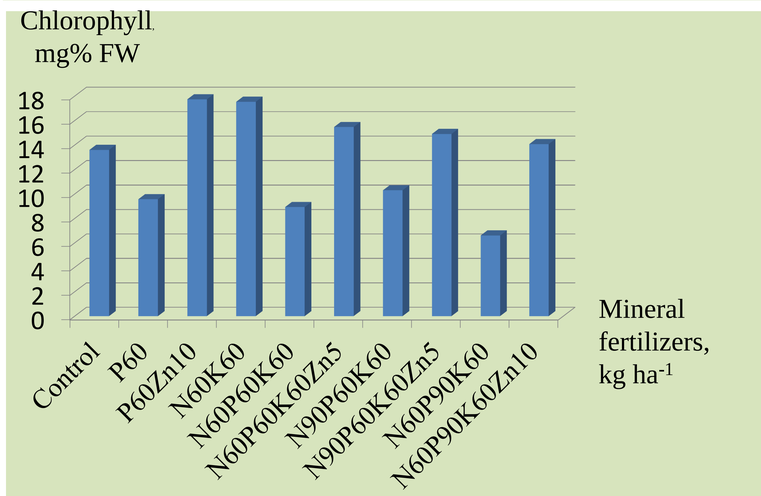

Fig. 3. Chlorophyll response to macro-and microelements at the 5-6 leaves stage

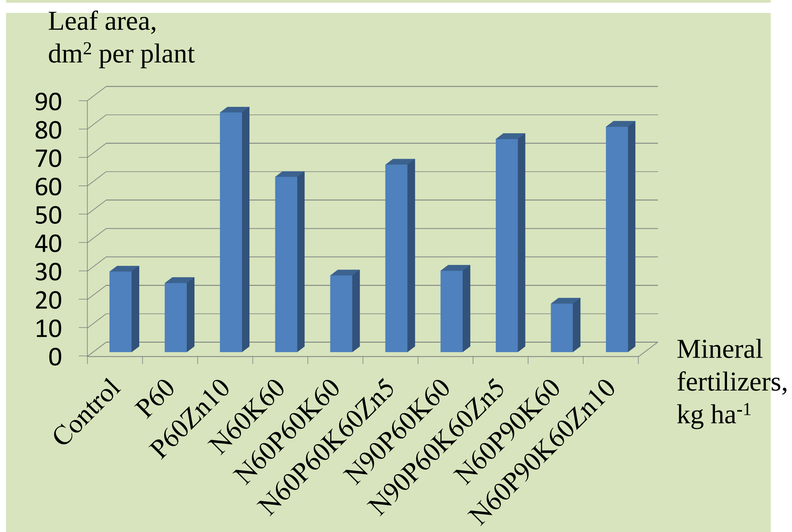

Fig. 4. Leaf area response to macro-and microelements at the 5-6 leaves stage

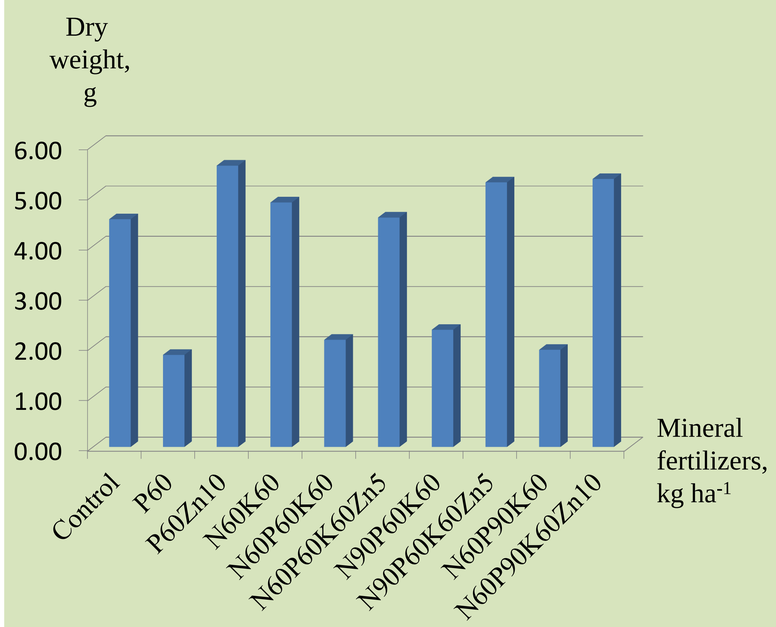

Fig. 5. Maize dry weight response to macro-and microelements at the 5-6 leaves stage

between monosaccharides in leaves or stems and leaf area values (r=0.73 and r=.83). The corn dry weight (DW) ranged on average 1.83–5.6 g per plant at the 5-6 leaves stage and was affected by macro-and microelements applications (Fig. 5). The combined application of phosphorus and zinc fertilizers increased corn growth by 2.44-3.77 g DW per plant compared to without zinc application at the 5-6 leaves stage. Plants fertilized with zinc had 2.4-3.0 times greater DW per plant than plants without zinc fertilization. The soil tests results in 0-20 cm revealed that zinc deficiency stress (stunted growth, leaves interveinal chlorosis and necrosis) of field corn, related to values of phosphorus/zinc ratio, which decreased from 95.1-104.3 to 26.2-32.3 after zinc sulfate fertilizer application. These results show that zinc application following prolonged use of phosphorus fertilizers is necessary for corn growth and development on carbonate chernozem soil.

Conclusion

The use of zinc sulfate following systematic application of phosphorus fertilizers to carbonate chernozem is important to increase corn chlorophyll biosynthesis and monosaccharides content. Phosphorus and zinc fertilization had significant effect on total monosaccharides content in leaves and stems as well as corn leaf area and chlorophyll content at the 5-6 leaves stage. Significant positive correlations were observed between monosaccharides in leaves or stems and chlorophyll content, as well as between monosaccharides in leaves or stems and leaf area values. These parameters are greatly associated with corn yield and can be used in corn nutrient management.

Literature Cited

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