The Influence of Zinc Fertilization on Bioavailable Zinc Content in Lentil

Muhammad A Maqsood[1], Jeff Schoenau[1], Sarah Anderson[1], Albert Vandenberg[2] and Tom Warkentin[2]
[1]Department of Soil Science, University of Saskatchewan, Sk
[2]Department of Plant Sciences, University of Saskatchewan, Sk

Project Description

- Zinc (Zn) is one essential nutrient that is deficient in the human diet in many developing countries where Saskatchewan lentil is marketed.
- Both genetic and agronomic approaches can be effective in increasing Zn concentration in grain of lentil.
- Estimation of Zn in lentils and its bioavailability to humans is prerequisite for an effective biofortification program.

Goals of Project

- The main goal of this project was to determine the variation among three market classes of lentils for Zn distribution in straw and grain and bioavailability in response to Zn fertilizer application to a Dark Brown Chernozem

Methods

- Homogenized soil from 0-15 cm of a Dark Brown Chernozem (Regina Association) were placed in 1kg pots. Basal dose of N,P and S was supplied to all pots. Zinc sulfate was used to supply Zn at a rate of 2.5 kg Zn ha^{-1}. Zinc was also supplied in foliar form (Zn-EDTA) at a rate of 0.246 kg Zn ha^{-1}. A popular CDC variety of each of the three (large and small green, small red) lentil classes (Impower, Imvincble, Maxim) was grown on each soil. Half of the lentil plants were harvested at 30 days after seedling emergence and the remainder at maturity. Harvested plants were further separated into lower and upper shoots and analyzed for Zn concentration.
- Harvested grain samples were also analyzed for phytate-P content following a modified method of Gao et al. (2007). Mineral bioavailability was qualitatively estimated as [phytate]:[mineral] ratio in grains (Brown et al. 2001). Zinc bioavailability in lentil grain was also quantitatively estimated by employing the trivariate model of Zn absorption (Miller et al. 2007):

$$TAZ = 0.5 \cdot \left(A_{MAX} + TDZ + K_R \cdot \left(1 + \frac{TDP}{K_P}\right) - \sqrt{\left(A_{MAX} + TDZ + K_R \cdot \left(1 + \frac{TDP}{K_P}\right)\right)^2 - 4 \cdot A_{MAX} \cdot TDZ} \right)$$

Key Outcomes

- Zinc fertilizer application influenced grain yield and biomass partitioning in lentil classes. For example, in large green lentil class (Figure 1) there was a reduction in the biomass but increase in grain yield with application of Zn. The increase in grain yield was more pronounced with foliar Zn application.
- Application of foliar Zn fertilizer increased the shoot concentrations of Zn while soil application increased the grain concentration of Zn (Figure 2). Zinc is taken up over the season and eventually redistributed from the shoots to the grain.
- Reduction in grain phytate-P content was observed with Zn application. A significant decrease in the phytate:Zn ratio from Zn fertilization, indicating greater human bioavailability of the Zn, was only observed for the treatment with foliar application of chelated Zn to small green lentil (Figure 3). The molar phytate: Zn ratio in all lentil classes was less than 15, indicating high Zn bioavailability. Quantitatively estimated Zn bioavailability using the trivariate model in all lentil classes was $\geq$3 mg Zn / 300grams.

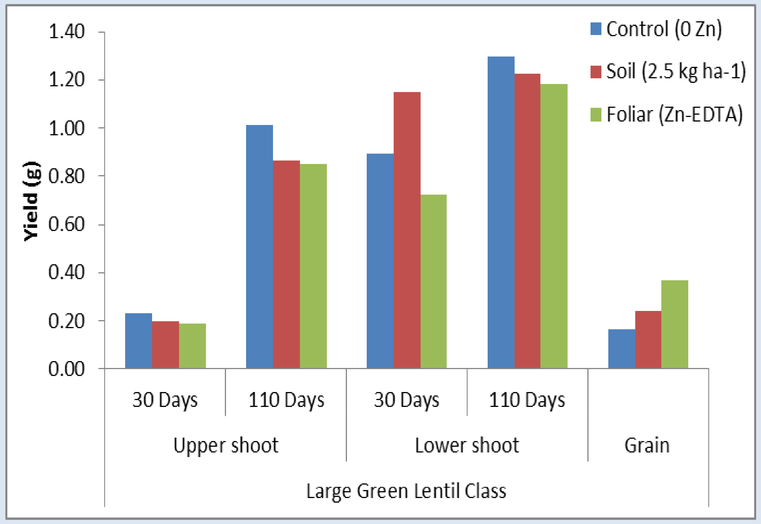

Figure 1. Influence of soil and foliar applied Zn fertilizer on straw and grain yield of Impower (large green lentil class) grown on a Dark Brown Chernozem.
*(*Plants were harvested at 30 days and maturity (110 days) and separated into lower and upper shoots*)

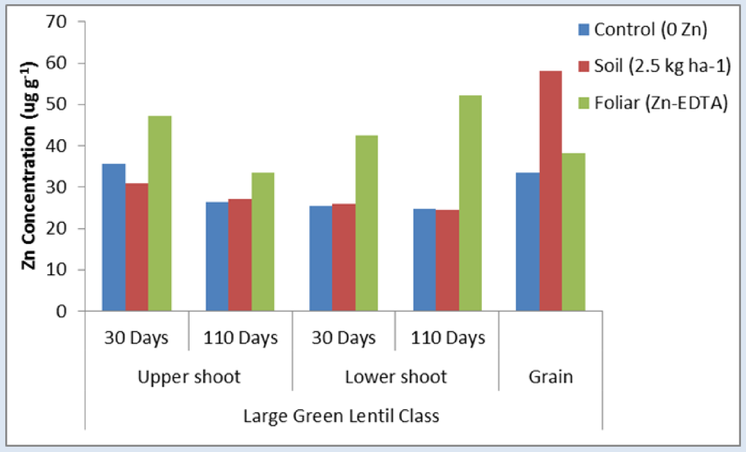

Figure 2. Influence of soil and foliar applied Zn fertilizer on zinc (Zn) concentration in straw and grain of Impower (large green lentil class) grown on a Dark Brown Chernozem.

Conclusions

- Application of Zn fertilizer increased concentration of Zn, reduced the phytate content, and in one market class (small green) increased the apparent bioavailability of the Zn in the lentil grain.
- Zn fertilization offers promise as a means of increasing the human nutritional value of lentil.

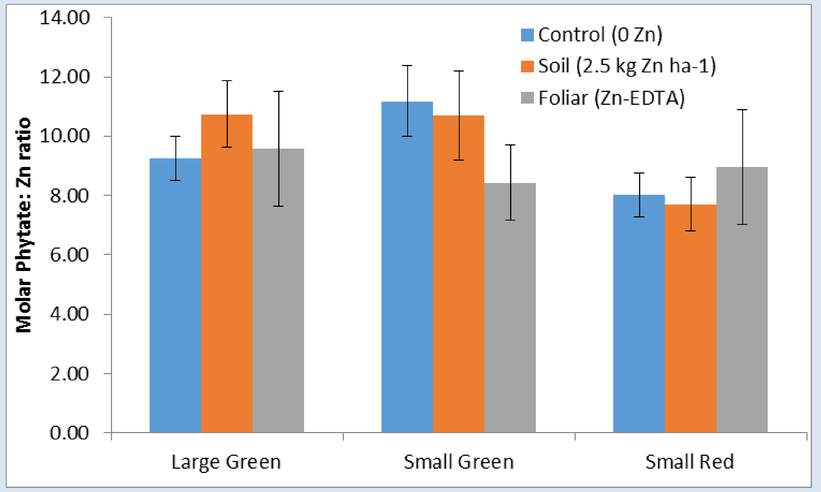

Figure 3. Influence of soil and foliar applied Zn fertilizer on molar phytate:Zn ratio in the grain of three market classes of lentil.

Acknowledgments

- Financial support from Saskatchewan Pulse Growers, Agriculture Development Fund and NSERC
- Thanks to Western Ag Labs, Saskatoon for soil nutrient supply rate analysis , Gary Kruger and Derek Derdall for help in soil collection