HOW SOIL HEALTH MIGHT CONTRIBUTE TO TYPE II DIABETES

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Background

- Two randomized controlled trials report that a vitamin and mineral supplement reduces infections in DMII[1,2]
  - Do diabetic patients lose nutrients?
  - Do diabetic patients need more nutrients?
  - Do nutrient deficits contribute to diabetes?
- Dietary Magnesium (Mg) deficiency is a dose-responsive risk factor for DMII[3]
- Mg and zinc (Zn) deficiencies are now common in people and soils worldwide[4,5]
- Genome-wide association studies (GWAS) link DMII to many enzymes that use ions (Mg^{++}, Zn^{++}, others) or vitamins (e.g. B_1, B_2, B_6) as cofactors[6]
- "Hidden hunger" for one or more essential nutrients might drive excess calorie consumption
- Toxic effects of copper (Cu), manganese (Mn), Zn, and other metals are posited to contribute to DMII[7]

Questions

1. Is synthesis of DMII-related vitamins dependent on Mg^{++} or Zn^{++}?
2. Does soil management affect DMII-related vitamin and mineral content of crops?

Methods

Vitamin synthesis

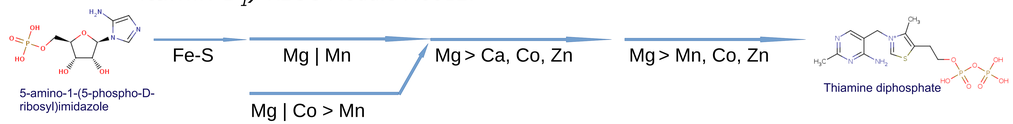
For each DMII related vitamin
- Find biosynthesis pathway (www.kegg.jp)
- For each biosynthesis step
  - Find enzyme
  - Find cofactors (www.brenda-enzymes.info)
  - Note Mg^{++} and Zn^{++} preference

Soil management & DMII nutrients

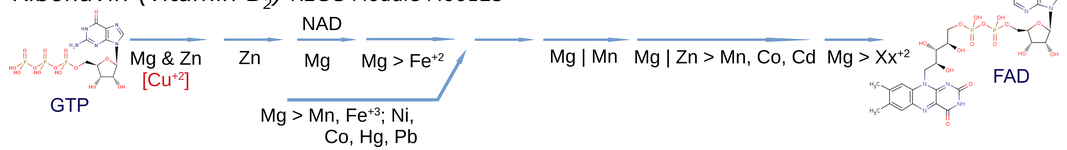
Divided 10,000 sq ft of farmland into four sections
Soil tested to guide amendments
Control: NPK fertilizer, lime ($CaCO_3$)as per Missouri extension
Intervention: Diverse amendments & compost as per Organicalc (growabundant.com/organicalc/)
Amaranth, rye, wheat, corn, beans, etc grown
Crops analyzed for kcal, Mg, Zn, Cu, Mn, $B_{2,6}$
Calculate kcal consumed per mg of nutrient

Results: Cofactors in DMII-related vitamin biosynthesis

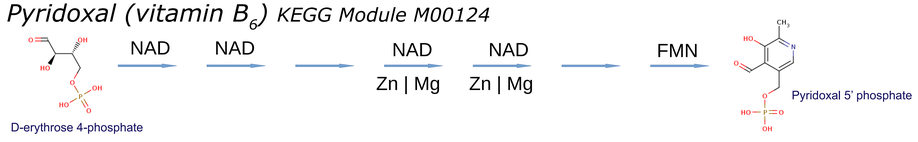
Thiamin (vitamin B_1) *KEGG Module M00127*



Riboflavin (vitamin B_2) *KEGG Module M00125*

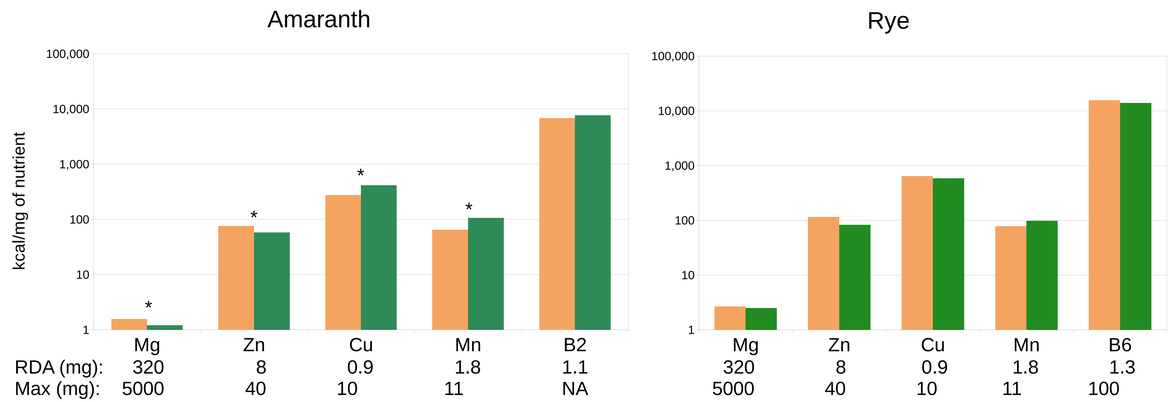


Pyridoxal (vitamin B_6) *KEGG Module M00124*



Multiple steps in these syntheses run fastest with Mg^{++} or Zn^{++} cofactors, which normally come from soil, but substitutions are often possible

Results: Soil management & DMII nutrients



Control
Intervention

* p<0.001

Compared to crops grown on conventionally fertilized control soil, crops from chemically balanced intervention soil were:
- More dense in Mg and Zn
  (need to consume fewer kcal to meet recommended daily allowance (RDA))
- Usually less dense in Cu and Mn
  (have to consume more kcal to exceed recommended maximum)
- Similar in B vitamin content

Conclusions

- Synthesis of DMII-related B vitamins is dependent on divalent cations in soil
  - Mg^{++} and Zn^{++} are usually preferred
  - Substitutes available if Mg or Zn are limiting
- Soil chemistry affects crop chemistry
  - Some effects may be crop-specific
  - Balanced soil produced seed crops that were
    - More nutrient dense for Mg and Zn
    - Less nutrient dense for Mn
    - Variable for Cu, and
    - Minimally different in B vitamins compared to conventionally fertilized soil
- Plants and/or supporting soil microbes may respond to scarcity of preferred metal cofactors by substituting others to sustain vitamin synthesis. This is most likely on intensively farmed land. Crops from depleted soils may exhibit mineral imbalances before vitamin deficiencies.
- Crop selection, CO_2 levels, processing, and food preparation can exacerbate mineral imbalances, remove vitamins, and/or add calories. Disease and medications, e.g. Mg^{++} wasting diuretics, can further exacerbate patients' homeostasis.
- A few clinical trials support use of multivitamins *with minerals* to reduce infection rates in DMII. Mg and Zn may be helpful if DMII is related to food quality, while other elements could be harmful.

References

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Acknowledgements

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