Cropping systems or agronomic approaches to improving nutritional quality

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Sasakawa meeting room, CIMMYT, El Batan, Texcoco
Agronomic biofortification

Lots of literature available

Harvest Plus
Breeding Crops for Better Nutrition

CIMMYT
Overview

• Role of agronomy in improving nutritional quality
• Some trials with Zn and Fe in Wheat
  – Donor parent characterization for agronomic traits and response to Zn application.
  – Soil vs Foliar Zn applications.
  – Foliar Zn applications combined with fungicides and insecticides
  – Planting date effect on grain Zn content and concentration
• Addressing Zn deficiencies in soils
Role of agronomy

• Management practices by farmers depend on what they expect to gain relative to the costs.
• Management is not only related to nutrient content but to a range of factors, so interactions are important
• Farming systems link agronomy to farmer goals and aspirations, their resource availability and the external biophysical and socio-economic constraints
Experiment 1: Donor parent characterization for agronomic traits and response to Zn application

- We first identified the high Zn and Fe donor parents among the wild relatives.
- We now move from wild relatives to landraces for the characterization of parents with better agronomic characteristics (e.g. grain yield, phenology).
- Identification of parents that are more responsive to Zn application
Conclusions

1. No yield effect on foliar Zn applications.
2. The facultative material, W-61, W-66 and Hung Dung Mang consistently had the highest Zn grain concentration, but were also among the lowest yielding lines.
3. There was no interaction between genotype and Zn application, suggesting that all genotypes benefit about the same.
4. The average response in grain Zn concentration to foliar applications was + 9 ppm.
5. Zn applications tended to increase Fe concentration by + 4 ppm but it was not statistically significant (perhaps in the multiyear analysis).
Experiment 2: Soil vs Foliar Zn applications

- Soil vs Foliar vs Soil + Foliar applications of Zn SO4.
- Soil applied rates, 50 kg ZnSO4/ha, pre-plant incorporated.
- Foliar applied Zn rates at 0.5% solution until all canopy wetted at boot and early milk stage.
- 0.5% solution ~ equivalent to 1 kg ZnSO4.
Conclusions

1. No yield response to soil or foliar Zn applications.

2. Soil applied vs boot stage vs milk stage were comparable in increasing grain Zn concentration, but much lower Zn rates were used in the foliar applications.

3. Soil applied + foliar at milk stage was the best treatment with a + 14 ppm increase compared to the control.

4. ZnSO4 applications had no effect on grain Fe concentrations.
Experiment 3: Foliar Zn applications combined with fungicides and insecticides

- Can we combine Zn fertilizer with insecticides and fungicides and have the same response on grain Zn concentration?
- Foliar Zn applications of 0.5% ZnSO4 solution.
Conclusions

1. No response of foliar Zn applications on grain yield.
2. There were differences among locations for grain Zn (28 vs 34 ppm) + 6 ppm.
3. Fungicides Folicur or Tilt not only did not reduce the response of foliar Zn application on grain Zn concentration but increased it. + 6 ppm
4. Insecticide Aflix (for aphids) did not reduce the response to foliar Zn application on grain Zn concentration.
5. There were differences among locations for grain Fe (28 vs 33) + 5 ppm.
6. Fungicides Folicur and Tilt + Zn increased grain Fe concentration + 2 ppm.
Experiment 4: Planting date effect on grain zinc and iron

- In the Indo Gangetic Plains large areas of wheat are planted late. However, due to the adoption of No-till more areas are planted earlier. What is the impact of this change in grain micronutrient concentration. Can we compensate the reduction in grain Zn concentration due to planting date with foliar Zn applications?
Conclusions

1. No effect of Zn application on grain yield.
2. Late planting increases grain Zn concentration by about (8 ppm without Zn).
3. If we apply Zn that difference can almost disappear (1 ppm).
4. Grain Fe concentration is not affected by planting date.
Soil conditions most commonly associated with zinc deficiency

- Low total zinc content (such as sandy soils low in organic matter)
- Neutral or alkaline pH (calcareous soils)
- High salt concentrations (saline soils)
- Low pH, highly weathered parent materials (e.g. tropical soils)
- Peat and muck (organic soils)
- High phosphate status
- Prolonged waterlogging or flooding (paddy rice soils)
Addressing Zn deficiencies

Yield increase and benefit-to-cost ratio on wheat and other crops in India

<table>
<thead>
<tr>
<th>Crop</th>
<th>Zn Rate (kg/ha)</th>
<th>Zn Cost (INR/ha)</th>
<th>Yield Increase (kg/ha)</th>
<th>Value of Increase</th>
<th>Benefit-to-Cost Ratio</th>
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<tbody>
<tr>
<td>Wheat</td>
<td>5.25</td>
<td>875</td>
<td>1430</td>
<td>20,735</td>
<td>24:1</td>
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<td>Rice</td>
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<td>1102</td>
<td>14,987</td>
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<tr>
<td>Maize</td>
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<td>1050</td>
<td>1521</td>
<td>19,925</td>
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<tr>
<td>Chickpea</td>
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<td>855</td>
<td>32,063</td>
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<tr>
<td>Lentil</td>
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<td>440</td>
<td>16,500</td>
<td>38:1</td>
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<tr>
<td>Groundnut</td>
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<td>690</td>
<td>25,875</td>
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<tr>
<td>Mustard</td>
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<td>230</td>
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<tr>
<td>Cotton</td>
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<td>945</td>
<td>430</td>
<td>16,125</td>
<td>17:1</td>
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</tbody>
</table>

Overall conclusions

- Zinc fertilization is effective in combating zinc deficiencies. High ROI
- Extra fertilization to increase zinc content can increase zinc content
- Foliar zinc application is most cost effective for deficiencies
- Combination of soil and foliar for highest biofortification results (economic analysis still needs to be done)
- Planting date matters but can be off-set with fertilization
- Positive interaction between biocide use and zinc fertilization
Thank you for your interest!

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