Improved Crops for Humanitarian Programmes (CIMMYT)

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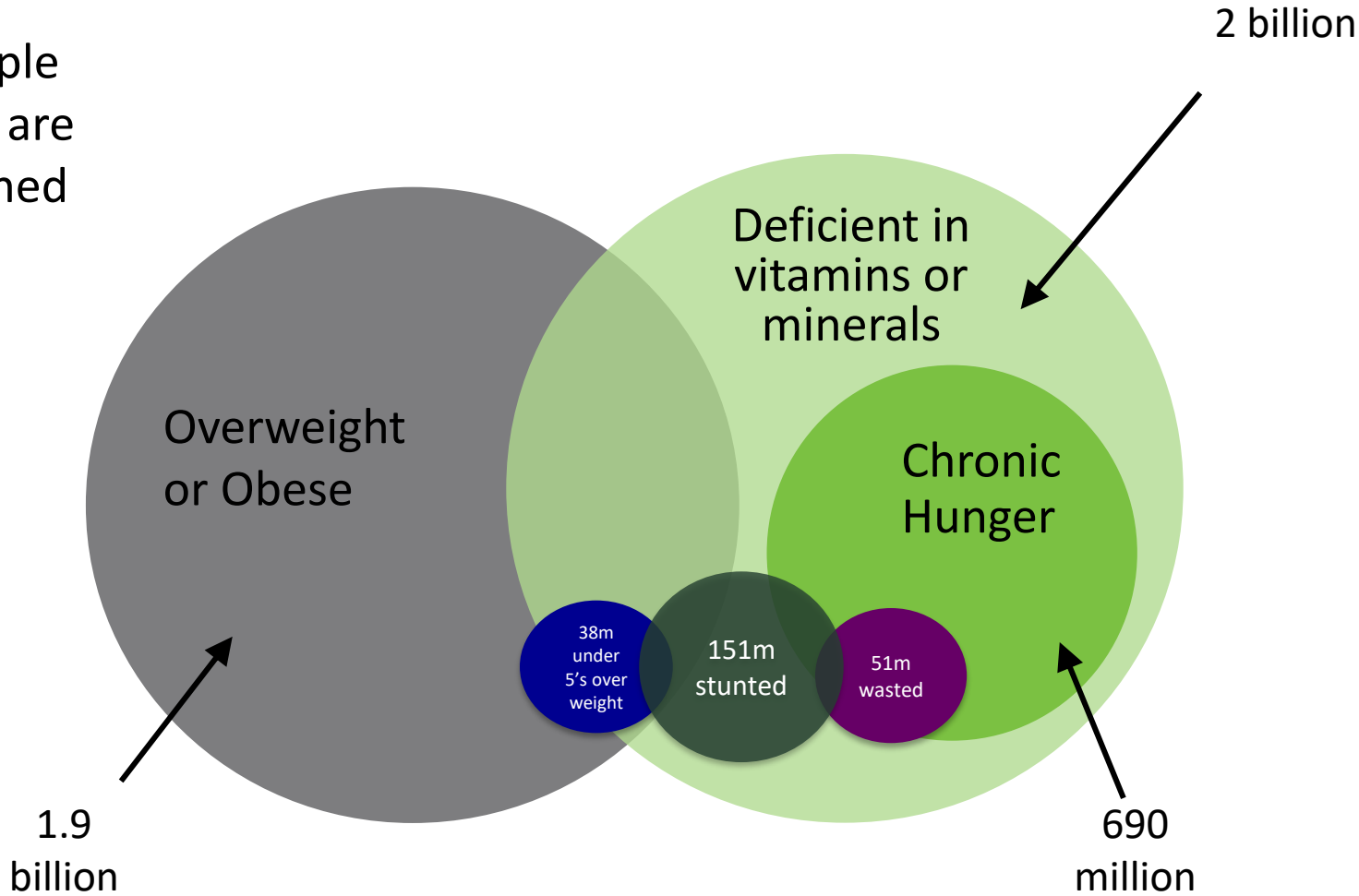
The Problem

1 in 3 people worldwide are malnourished



Slide Prof Haddard:GAIN

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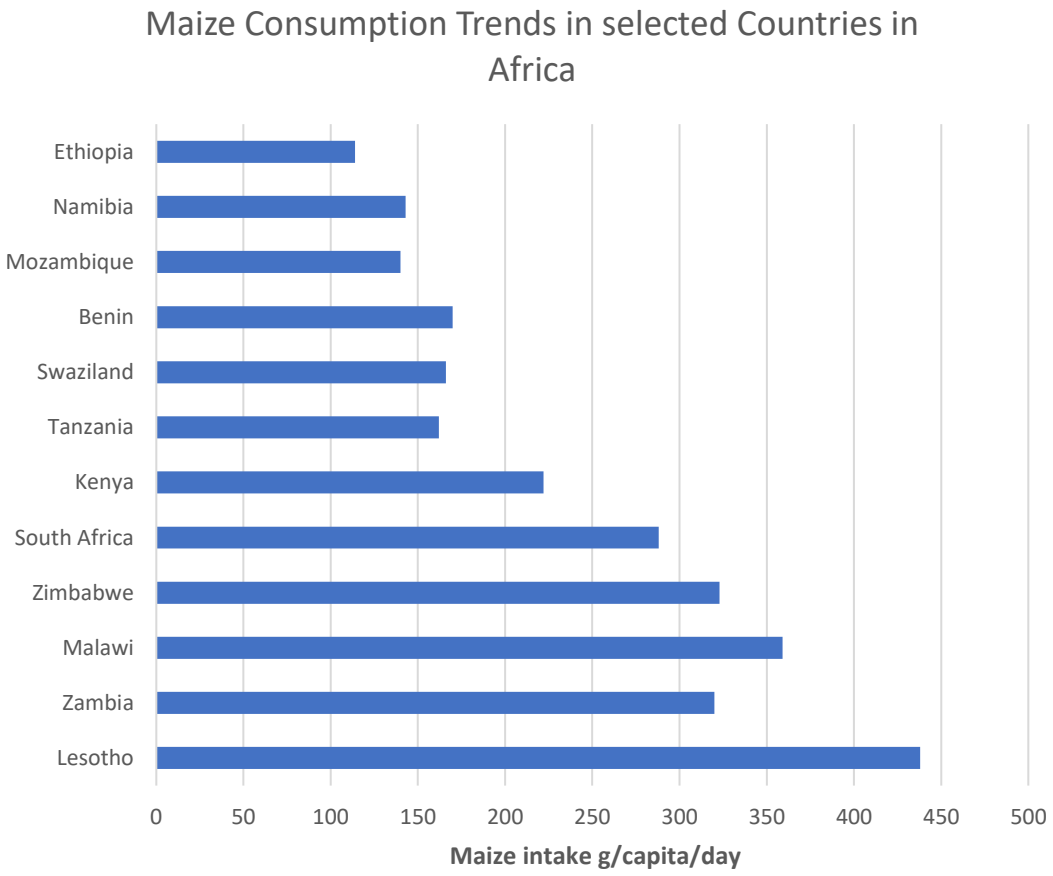
Maize intake trends in SSA

- Of the 22 countries in the world where maize forms the highest percentage of energy in the national diet, 16 are in Africa.
- About 95% of maize produced is used for human consumption and is predominatly white and **devoid of any micronutrients**



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Weapons to Fight Deficiency:

Supplementation

Commercial Fortification

2008+ WHO has invested 60M

Dietary Diversity

- Sustainable
- Targets major crops

Biofortification

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CIMMYT's current biofortification efforts

Provitamin A maize

15 ppm

Zambia
Zimbabwe
Malawi
Tanzania
Colombia
Pakistan
Ethiopia

Quality Protein Maize (QPM)

> 0.07% tryptophan

> 0.3 Lysine

Ethiopia
Pakistan
Zimbabwe
India
South Africa
Malawi

High kernel-zinc maize

33 ppm

Guatemala
Nicaragua
Colombia
Ethiopia

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What is provitamin A maize?

- Maize naturally accumulates carotenoids (precursors of vitamin A) (Wurtzel et al, 2012)
- Provitamin A carotenoids
  - **β - carotene**
  - **β-cryptoxanthin**
  - **α -carotene**
- PVA content in white maize 0 µg/g
- PVA content (average) in yellow maize 2 µg/g

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Pro-vitamin A maize

1270 MT seed produced 2019/2020

In 2019-2020, PVA maize seed demand grew **1,324%** in **Tanzania**, **28%** in **Zambia** and **55%** in **Zimbabwe**

Total number of PVA varieties released: **10** in **Malawi**, **11** in **Zambia** and **5** in **Zimbabwe**

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Evidence of efficaciousness of provitamin A maize

Photo: UNICEF

Photo: Matthew O'leary

- Consumption of provitamin A enriched maize has been demonstrated to improve total body vitamin A stores as effectively as supplementation (Gannon et al, 2014)
- Significantly improves visual function in marginally vitamin A deficient children (Palmer et al, 2016)
- Efficient conversions from provitamin A to retinol reported (Bouis & Saltzman, 2017)

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Quantifying combined interventions under farmer management to reduce nutrient gaps

Work is under using a randomized control trial (RCT) to quantify how much biofortified maize and beans with improved agronomy combined with intensive Infant and Young Child feeding (IYCF) can reduce nutrient gaps

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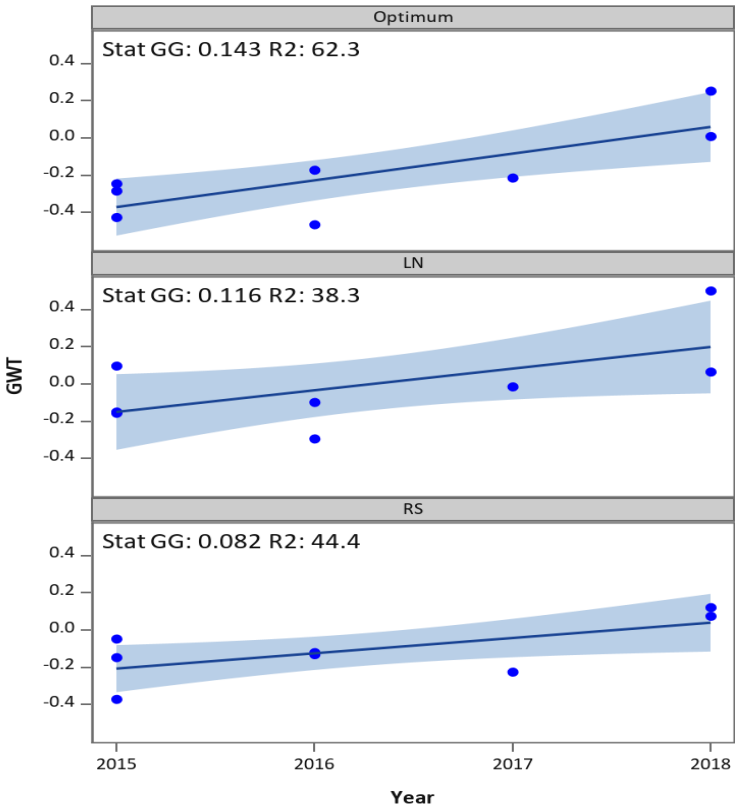
Increasing yields of provitamin A maize

- Estimated genetic gain is 0.14 t/ha per year under optimum conditions
- 0.12 t/ha genetic gain per year under low N (LN) stress
- 0.08 t/ha genetic gain per year under random stress (RS) conditions
- The rates of genetic gain are comparable with those reported for conventional maize breeding pipelines.



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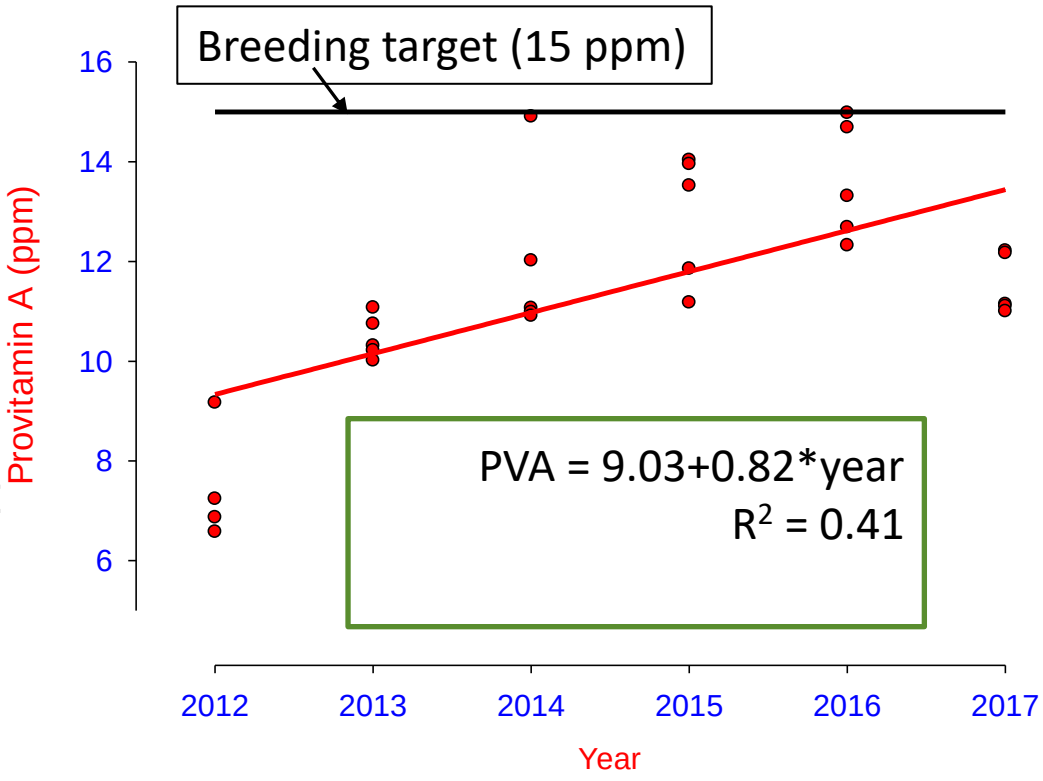
Increasing provitamin A content

- Provitamin A content of selected hybrids from advanced trials increased at an average 0.82 ppm (9.1%) per year from 2012 to 2017
- The high rate of increase is consistent with the high heritability estimates reported for the trait
- Hybrids with >90% of the PVA breeding target of 15 ppm have been identified but agronomic issues like maturity are being fixed



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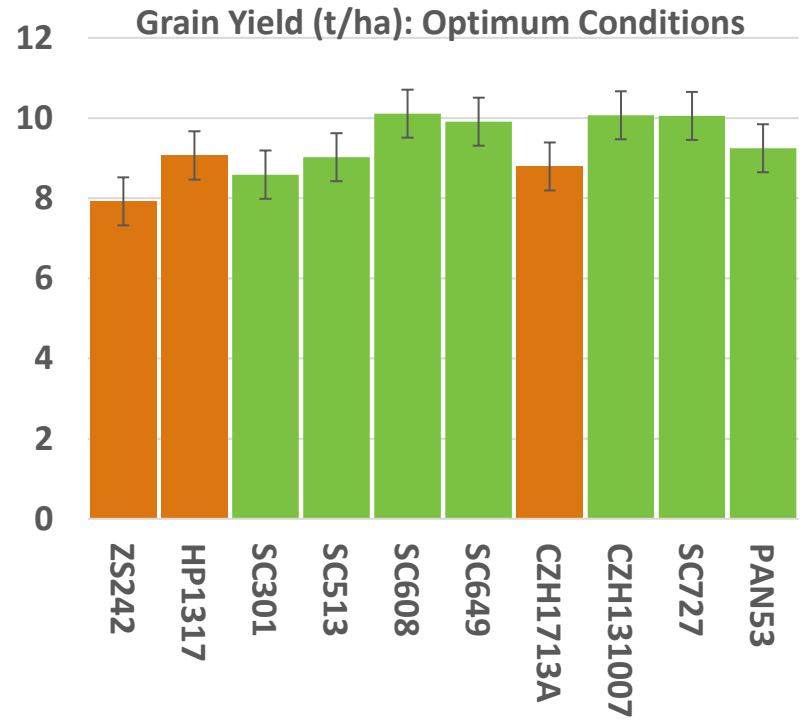
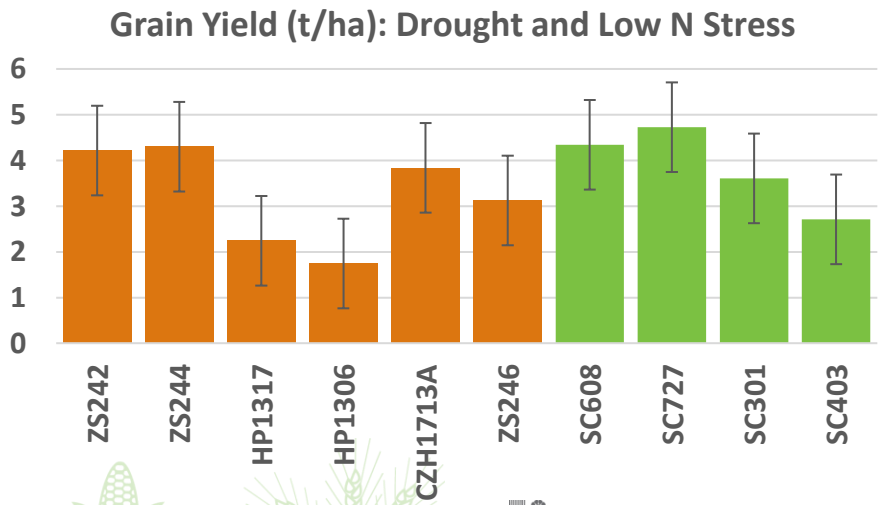
Competitiveness of PVA hybrids

- Data from >10 environments comparing the most popular commercial and PVA hybrids
  - **Grain yield of PVA hybrids is similar to that of conventional hybrids of the same maturity (medium) group**, e.g., the yield of HP1317 is similar to that of PAN53 and SC513 under optimum conditions
  - PVA hybrids are 10-15% lower-yielding that the late maturing hybrid, SC727, under optimum conditions. This difference in yield is expected because PVA hybrids are generally early to medium in terms of maturity
  - **PVA hybrids are competitive with the early hybrids SC301 and SC401 under drought and low N.**
  - We need a late maturing PVA hybrid to compete with the late maturing commercial hybrids. Work is already in progress to develop late maturing PVA hybrids in Zimbabwe





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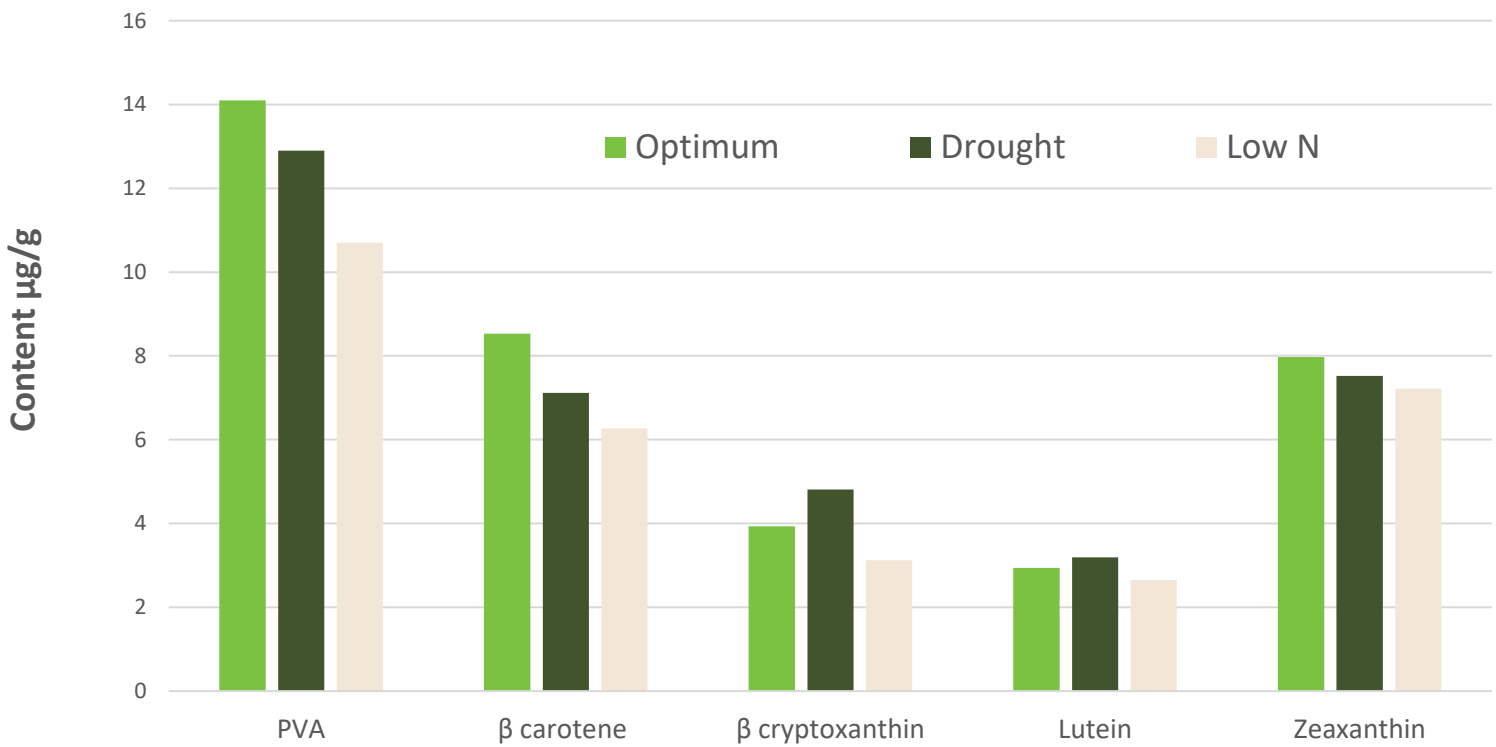
(Genetic) biofortification



Provitamin A content and individual carotenoids of pro-vitamin A hybrids under different conditions

Yadhira et al 2019

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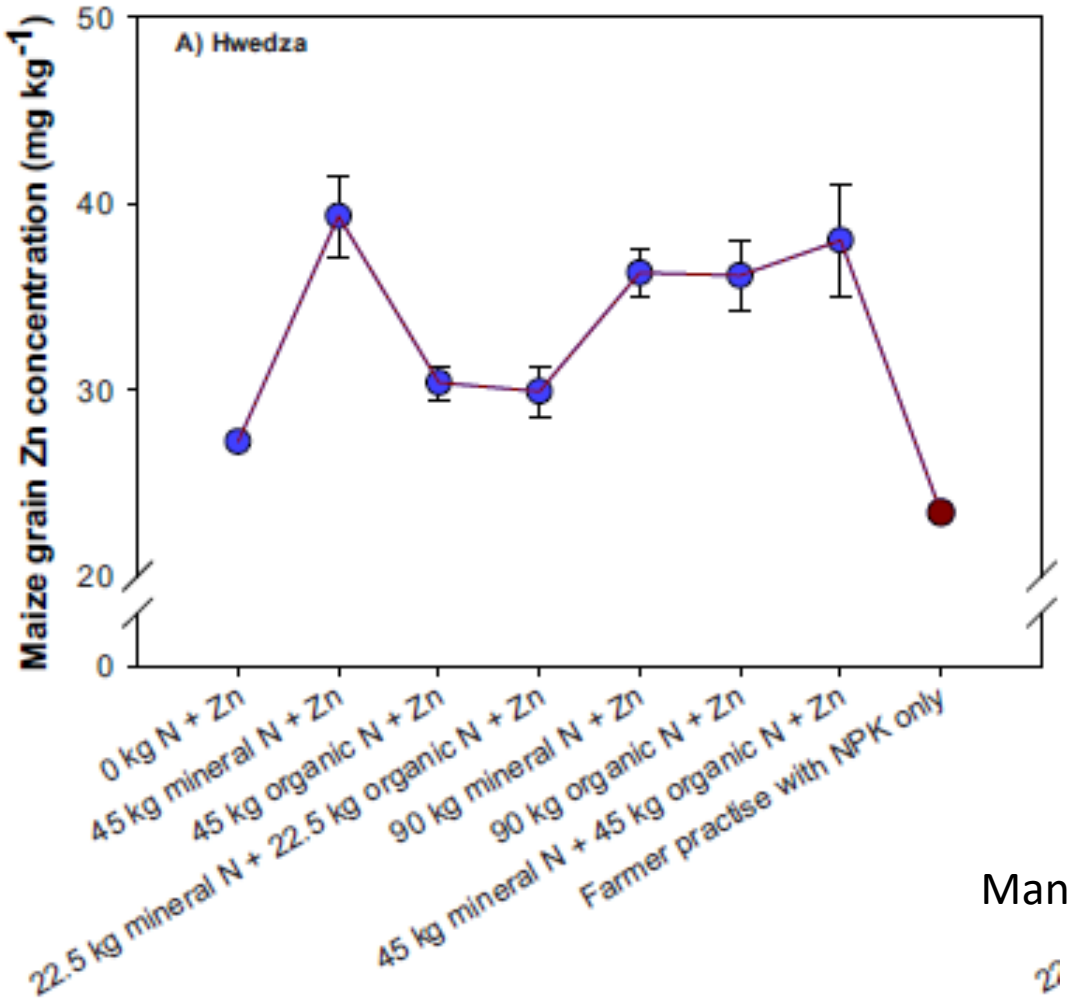
Maximizing nutrition through agronomic interventions



Manzeke et al. 2020

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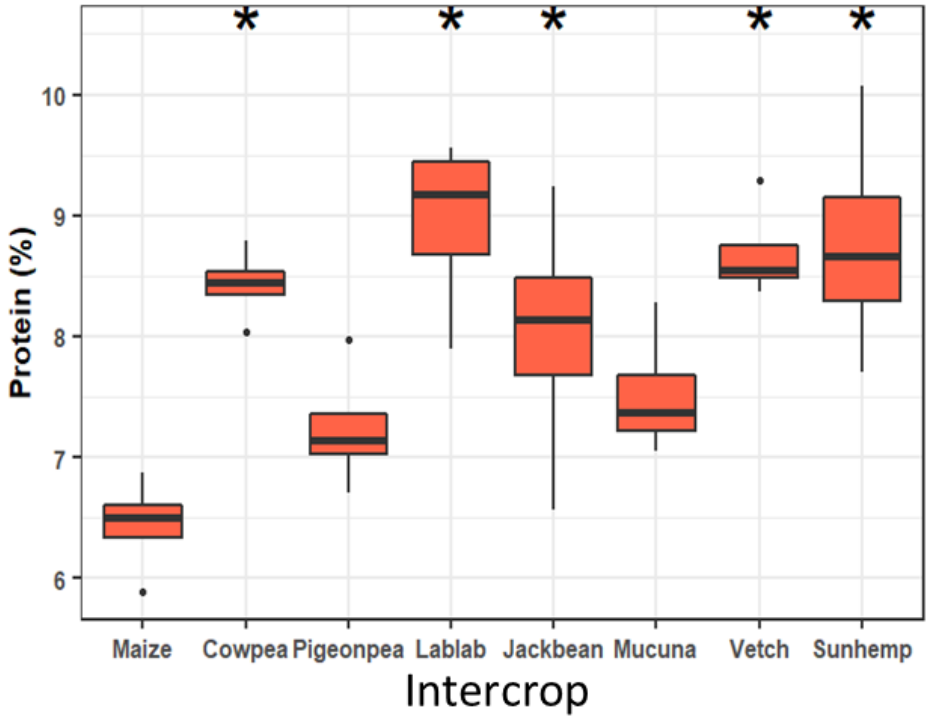
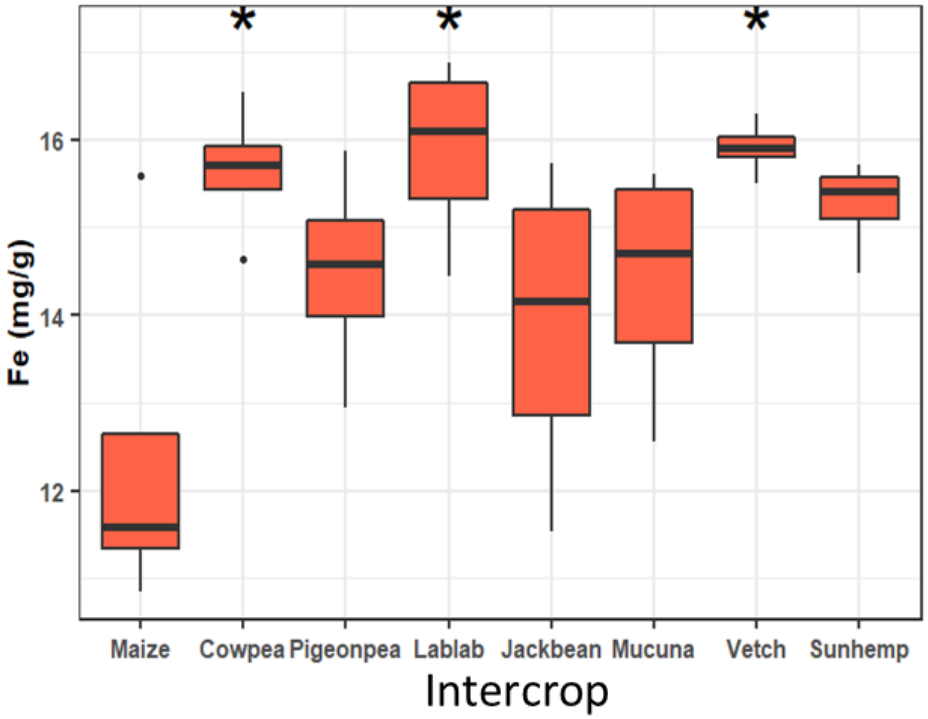
Maximizing nutrition through agronomic interventions





- Management practices proven important in increasing nutritional content of maize
- Lower nutritional content observed in the control (maize after maize)

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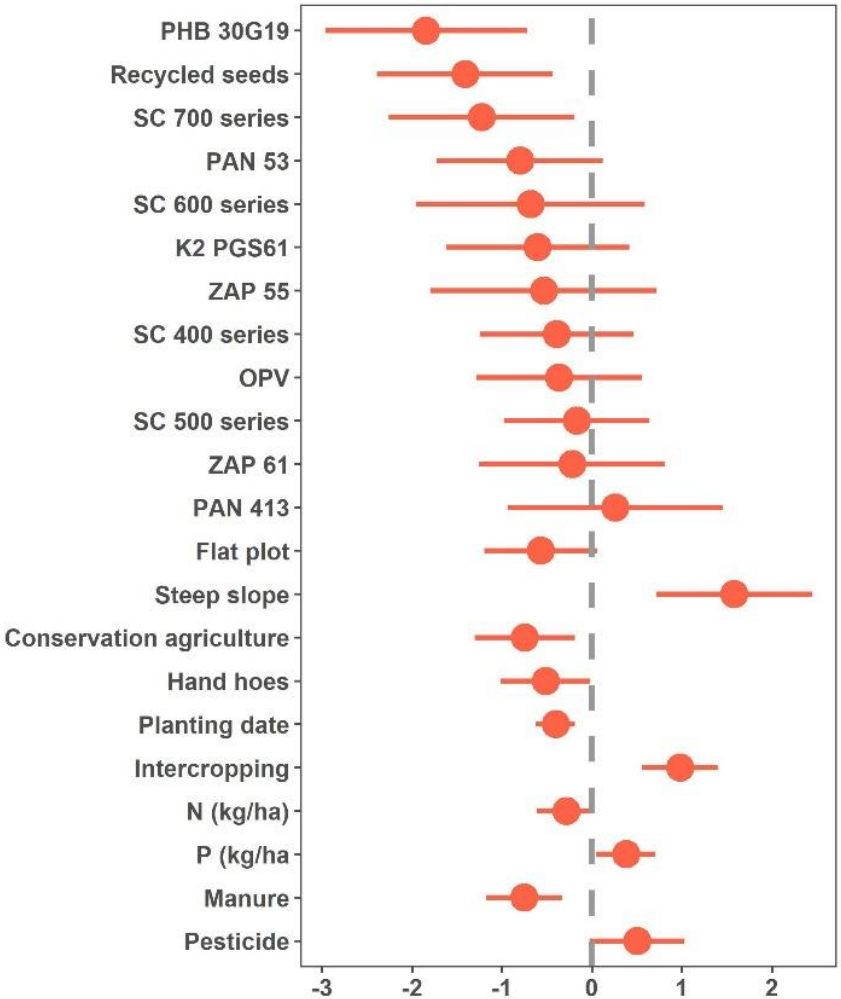
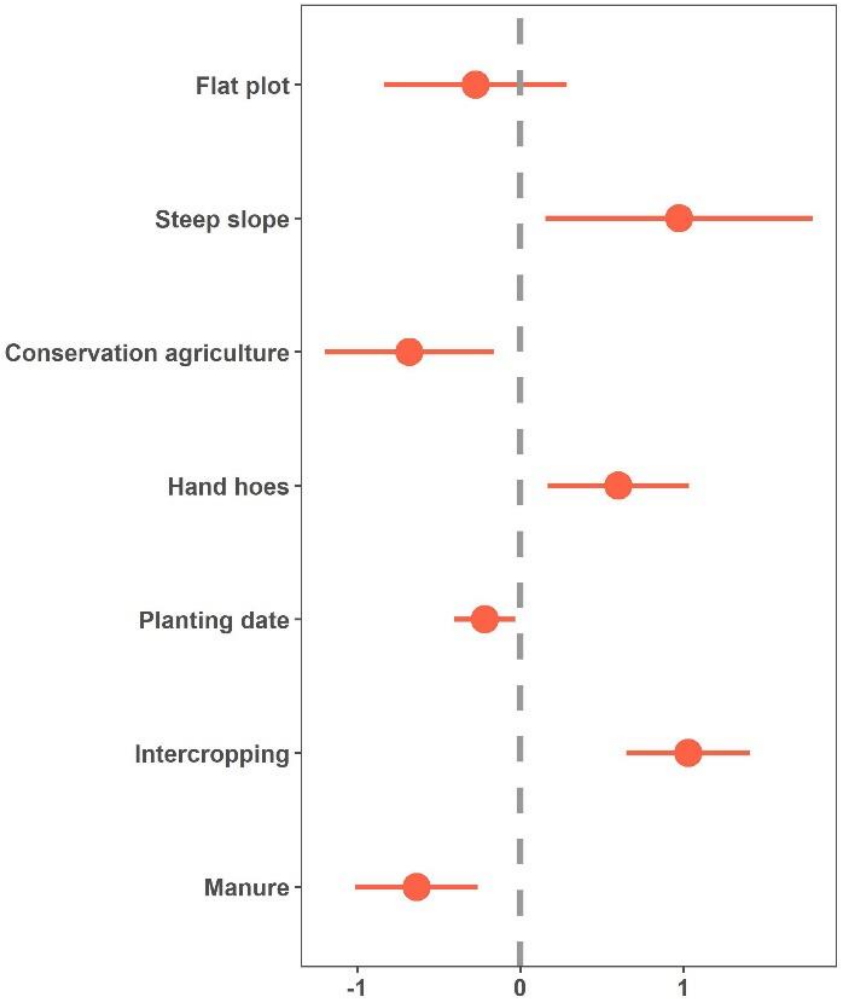
Gender Component In Management

A. Probability of a maize plot being managed by a woman

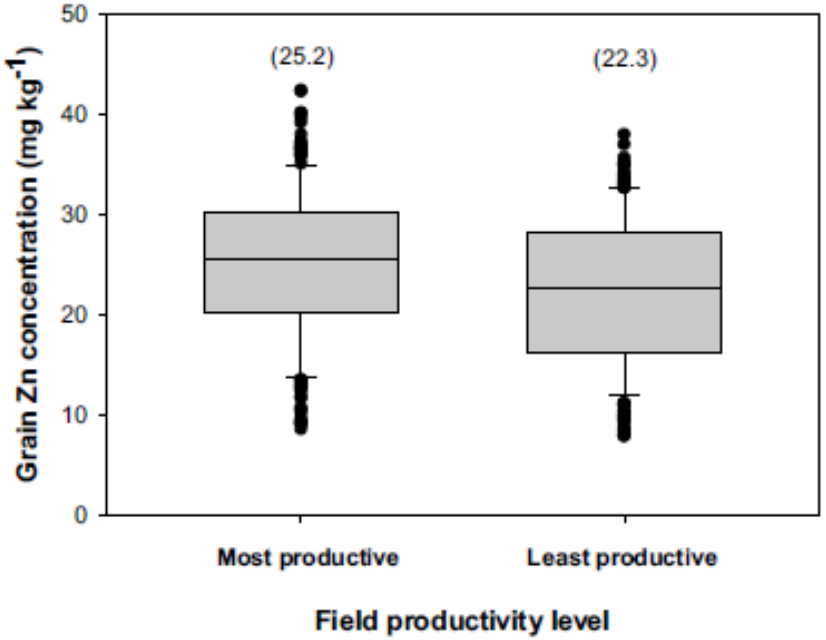


B. Probability of a maize plot being within a female-headed household



Spatial variation within homesteads

Poorer nutritional content of outfields translates to lower nutritional content of the grain



Manzeke et al. 2019

Figure 5. Grain Zn concentration in all crop types with respect to field productivity level in Hwedza and Mutasa. *Boxes* represent interquartile range (IQR) and the *midline* represents the median. *Whiskers* represent largest and smallest concentrations within 1.5*IQR of the box ends. Values in parentheses represent mean grain Zn concentration for most and least productive fields.

Spatial variation within homesteads will influence the nutritional content of maize

Homefield

Outfield

Onfarm trials in Ward 4, Murehwa

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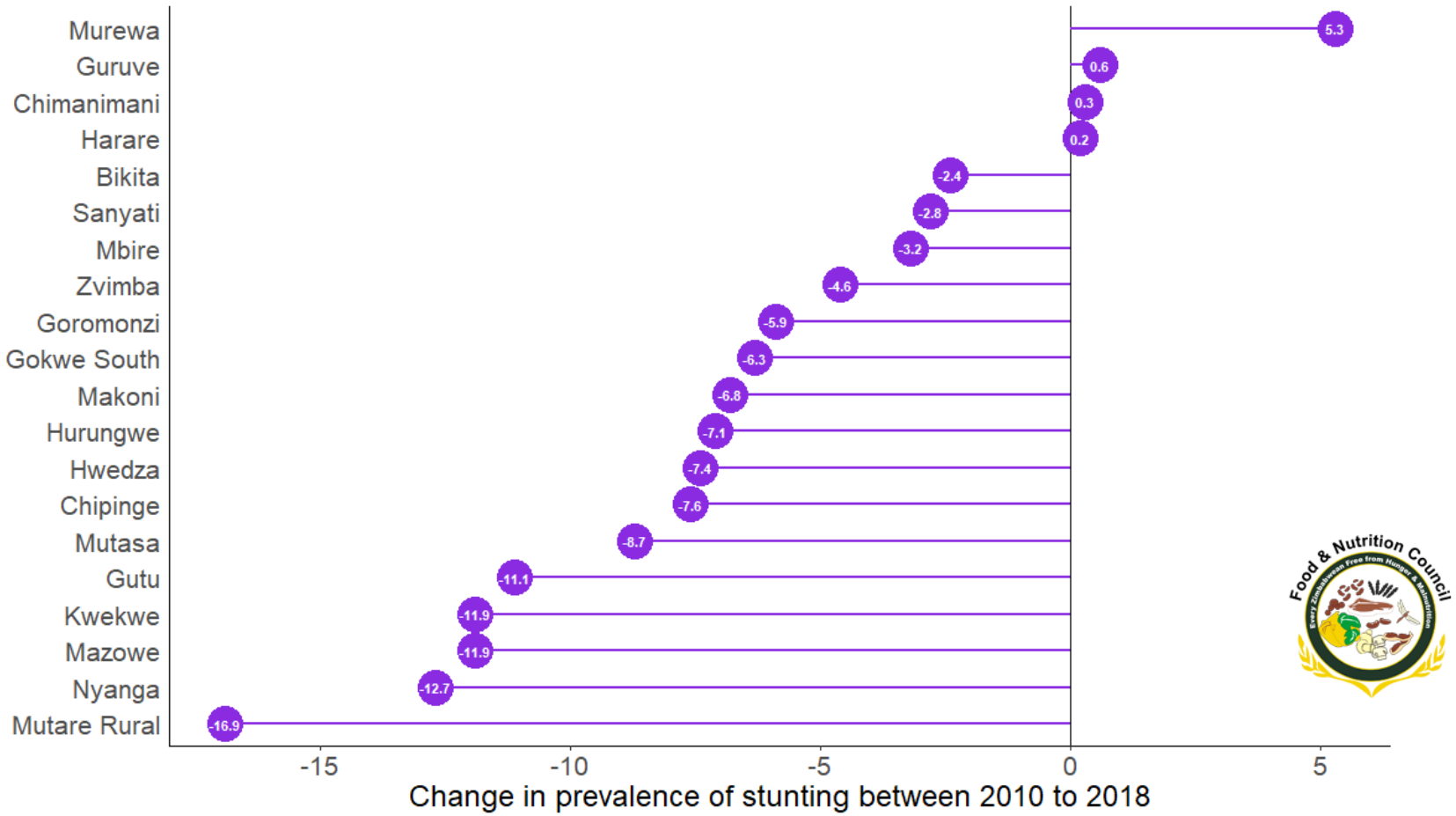
Targeted District



Food & Nutrition Council. Zimbabwe National Nutrition Survey, 2018.

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Conclusions

Biofortification is a cheap and effective means to increase nutritional food security

Agronomic measures can be used to “boost” nutrition

Work is ongoing to quantify the impacts of genetic and agronomic biofortification on health outcomes under smallholder farmer conditions

Thank you for your interest!

Biotechnology and Biological Sciences Research Council

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