



Opportunities to Improve Human Nutrition through Food Crops

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Studies Reveal Evidence Of Staggering Nutritional Deficiencies

Think you can achieve good health by eating a healthy diet? The information contained in this article, some of it shocking, will convince you otherwise.

According to a US Senate Report (Document 264) published in 1936, most of the farmland in America had by that time become seriously depleted of minerals. The report went on to suggest that 99 percent of the population who were then dependent on American-grown foodstuffs were suffering from significant mineral deficiencies.

Since that time, things have gotten worse, much worse. In 1992, the Earth Summit in Rio De Janeiro presented conclusive evidence that on average, American farmland was

supplement to remain healthy. Taking vitamin and mineral supplements is no longer a luxury; it's a necessity.

If it's not in the dirt, it's not in your dinner.

How did the richest farmland in the world become the depleted wasteland of poor nutrition that it is today?

Modern commercial practices are only part of the answer. The problem began a long time ago.

The 19th Century settlers who migrated to the vast breadbasket of the American Middle West often farmed the soil with-

Disastrous mismanagement of our soil and intensive farming methods have created such poor food quality that nutritional supplements are not a luxury but the bread and butter of robust good health.

Why should agriculture be the main strategy to address malnutrition

1. Food is the main source of calories and nutrients
2. Rural populations in developing countries do not buy processed foods
3. It is the only sustainable approach for the rural poor

Several Nutrition Issues

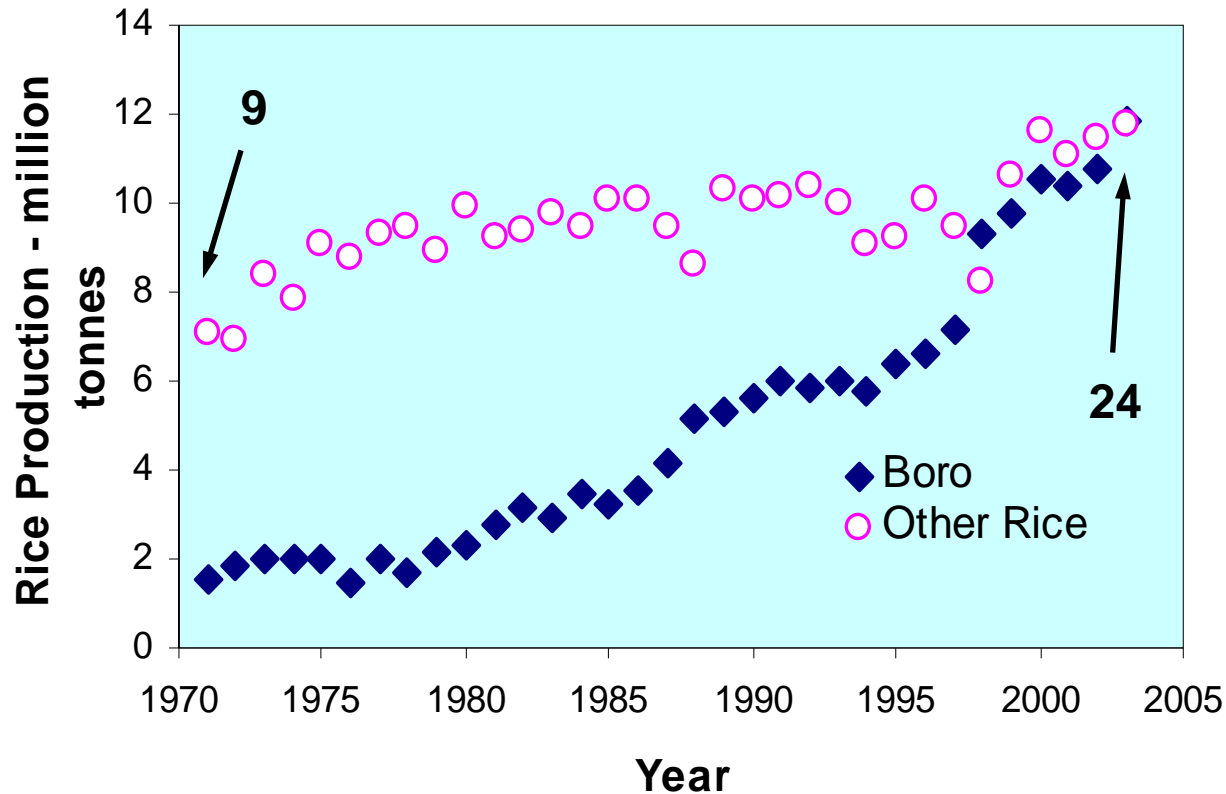
- Protein/energy malnutrition
 - *Insufficient & poor quality food*
- Micronutrient malnutrition
 - *vit. A, I, Fe and Zn*

Grain Legumes in South Asia

- Many vegetarians
- Traditional diet of cereals and grain legumes provided energy, protein (including balanced amino acid supply) and mineral micronutrients
- Green revolution emphasis on cereals led to increase in energy supply but decrease in availability of grain legumes
- Rice based diets are the least nutritious and rapidly digested starch promotes type 2 diabetes

Bangladesh

- Rice based diet 70+ % of energy and nutrients



Constraints to Grain Legume Production Not Addressed



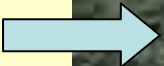
+ Mo

No Mo

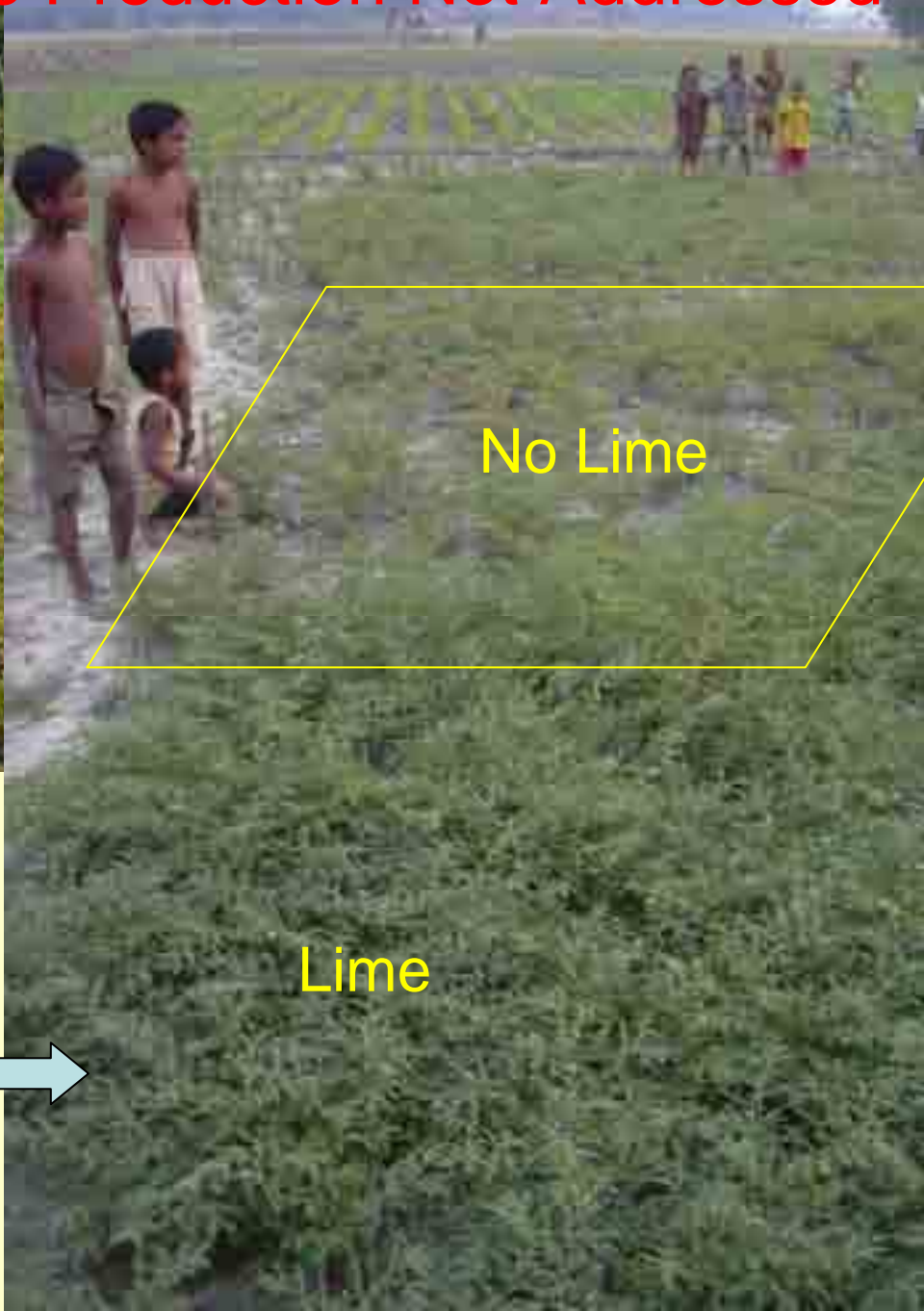
CONTROL



Seed Priming with Mo



Liming



No Lime

Lime

Cropping Systems

- Conservation Agriculture Approach Increases
 - crop productivity (economic return)
 - resource use efficiency
 - sustainability
(reduced tillage, residue return)
- ? How to fit legumes into a cropping system

Rice - Wheat - Mungbean triple crop rotation



Improved germplasm

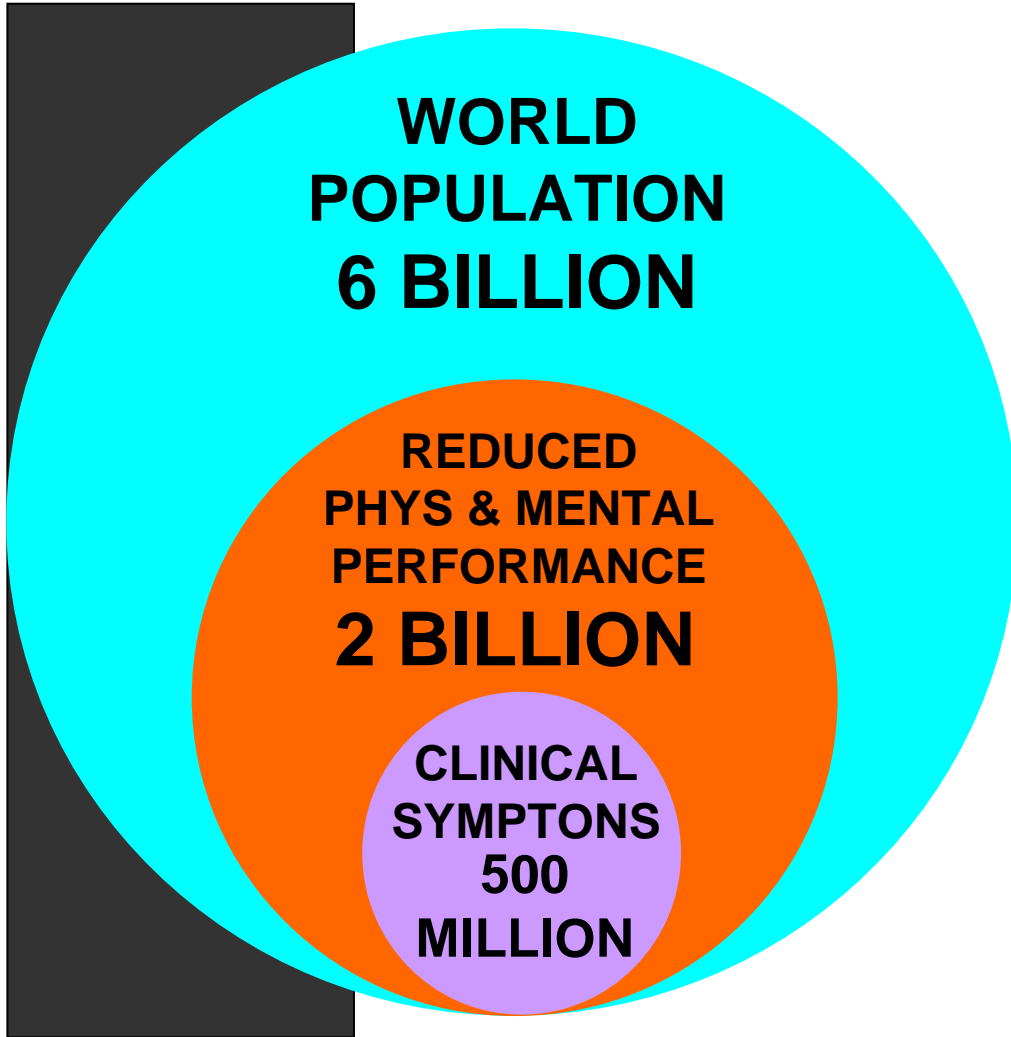


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Farmer Outcomes of Permanent Raised Beds

- Increased crop yields 15-25%
- Reduced production costs; savings of
 - 20-50% irrigation water
 - 30% seed
 - 15% fertilizer & pesticides
 - 30% tillage
- Increased income: \$43/ac. cereals
\$120/ac. mungbean
- Disposition of mungbean
 - 16% consumed
 - 10% given to relatives
 - 74% sold



Micronutrient Malnutrition

- Vitamin A
- Fe
- I
- Zn

- Se

from Emory University

Iodine addition to Irrigation Water

- Location: Xinjiang Province, China
 - high incidence of I deficiency & salt iodization unsuccessful
 - 3 districts, 26 villages, ~37,000 pop.
- Addition of KIO_4 to irrigation water (wheat and vegetables)
 - cost 5-12 cents/cap; less than iodization of salt



Sources: Cai et al., 1994. Lancet 344:107-110

DeLong et al., 1997. Lancet 350:771-773

Iodine addition to Irrigation Water

Outcomes

- ~ 50% decrease in neonatal and infant mortality
- 3 to 5x increase of iodine in soils, crops, vegetables, meat and urinary iodine
- Sheep production increased 35-63%
- More food, better food and increased income

Se addition to Fertilizer in Finland

Background

- 1970's
 - countrywide risk for Se deficiency (cardiovascular disease & cancer) with average daily intake ~ 30 µg/cap
 - widespread animal Se deficiency; commercial feed supplemented with Se in 1969 but little transfer to meat or milk (inorganic Se used)
 - 70% of Se intake from meat & milk
- 1984 decision to add Se to solid NPK fertilizers as the best strategy to achieve countrywide safe levels in humans
 - ***incorporate Se into organic forms in forage where get transfer to meat and milk, and in cereal grains***
 - ***using food system as a buffer to avoid toxicity risk associated with mineral supplements***

Source: Proc. Symp. 20yr of Se fertilization, Helsinki, 2005

Effects on Food Se Levels

Food	Se Content (mg/kg dw)			
	1984	1990	1996	2002
Cereals	0.01	0.27	0.03	0.10
Milk	0.05	0.20	0.14	0.22
Meat	0.20	0.90	0.38	0.60
<i>Dietary Intake</i>	<i>0.04</i>	<i>0.11</i>	<i>0.08</i>	<i>0.08</i>
<i>mg/day</i>				

Before Se addition at
16 and 6 mg/kg solid NPK
fert. for cereal and forage
crops, respectively

Changed Se
to 6 mg/kg
- all crops

Increased Se
to 10 mg/kg
- all crops

Current recommended intake 0.05-0.07 mg/cap/day
up to 0.2 mg/cap/day for non-nutritional benefits

Se addition to Fertilizer in Finland

Outcomes

- Human serum levels increased from 0.7 to 1.4 $\mu\text{mol/L}$
- Liver Se stores in male traffic accident victims increased from 0.93 to 1.58 mg/kg dw
- Mortality rate from heart disease decreased to one-third
- Effects on cancer rates variable from none to moderate

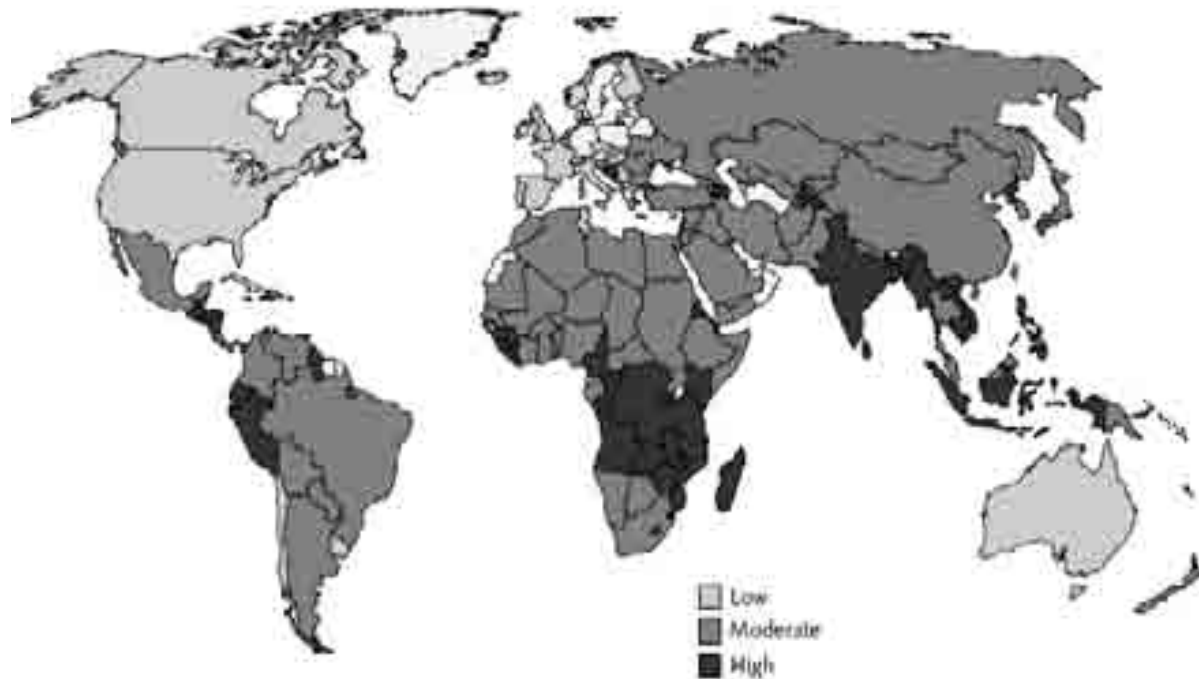
Laatikainen et al. 2005, Am J. Epidemiology. 162: 764-773

Increasing Zn in Wheat

Background

- 31% of global population thought to be Zn deficient
- Zn deficiency has no unique physical symptoms, but is involved in stunting and slowed cognitive development
- Zn has important role in membrane integrity and in many enzymes
 - membrane function affects diarrhea, respiratory infections (including malaria), and possibly even AIDS

Increasing Zn in Wheat



Human Zn Deficiency Risk

	% of Population Inadequate Stunting Intake	
Risk	Intake	
High	> 25	> 20
Inter.	↕	↕
Low	< 15	< 10

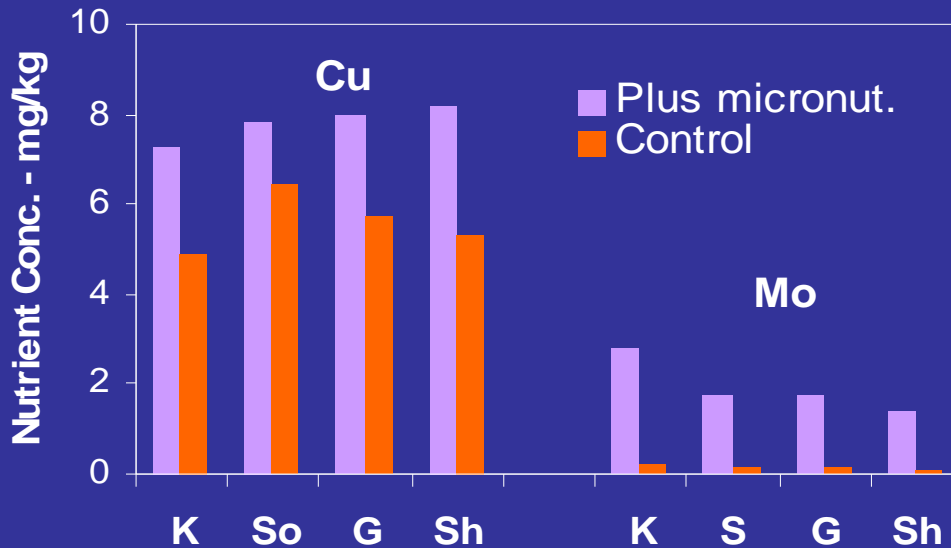
from Holtz and Brown, 2004. Food and Nutr. Bull. 94:S94-S203.

Foliar Application of Zn on Barley Field



Cakmak et al., Plant and Soil, 1996,

Micronutrient Enrichment of Different Wheat Varieties in Bangladesh



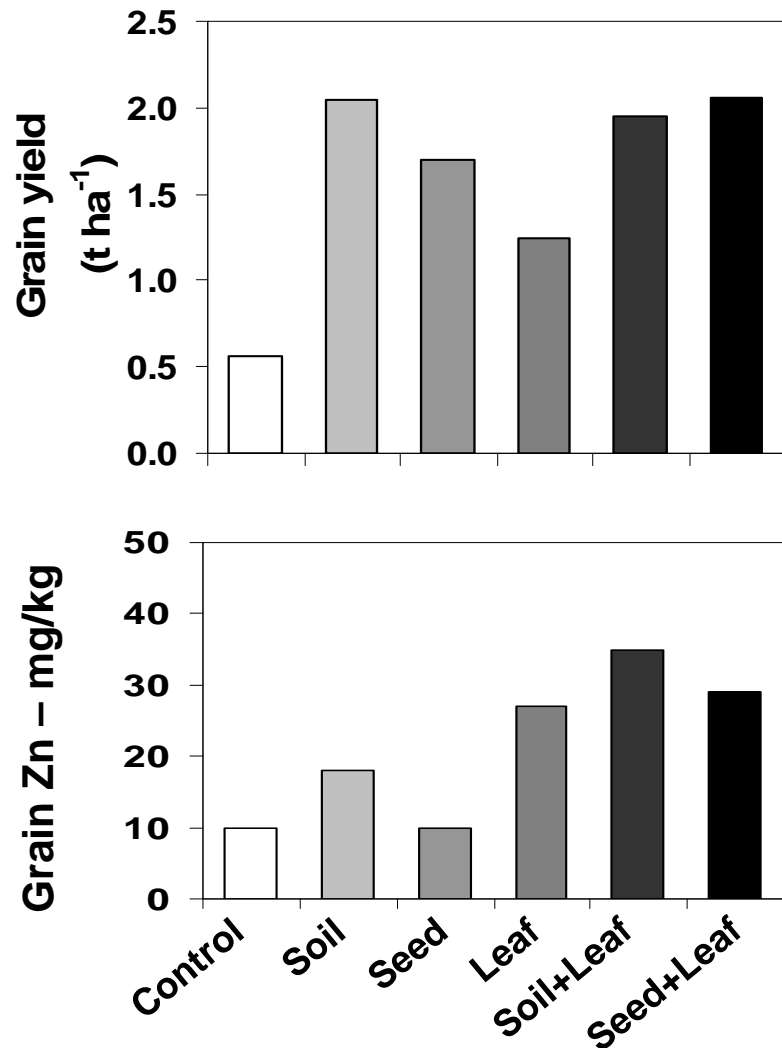
Zn levels (55-65 mg/kg similar to grain legumes (acid soils))

Zn in Seed Gives a Healthier Plant

- Improves root health and provides resistance to soil plant diseases and abiotic stresses (e.g. drought, low temperature)
- Greater seedling survival and vigor (saves \$50 million/yr in seed costs in Turkey)



Effect of Zn Fertilization on Grain Yield and Zn Concentration of Wheat, Turkey



Yilmaz et al., 1997; J. Plant Nutr.21:2257-2264

Conclusions

- Current knowledge and improved varieties can improve grain legume productivity
- Nutrient additions (fertilization) can increase agricultural productivity and the mineral nutrient content of foods directly and indirectly, i.e. effects can be much broader than on the target crop
- Soil and crop management (agronomy) is one of several agricultural strategies to improve the nutritional value of developing country food supplies

Conclusions

- Nutrition and Health Community should demand that the agriculture sector provide food output that meets the nutritional need of populations