Improving soybean for production under P limited conditions (MRA 1 - Fritschi)

Major Limitations to Crop Production in Africa:

- Soil erosion: wind and water
- Effective rainfall - infiltration / runoff, percolation
- Soil organic matter - hard to increase
- Soil pH - nutrient availability
- Nutrient limitations: N, P, ... incl many micronutrients
- P fixation on Fe and Al oxides
Global Soil Phosphorus Distribution


## Soil pH and Nutrient Availability

<table>
<thead>
<tr>
<th>Strong acid</th>
<th>Medium acid</th>
<th>Slightly acid</th>
<th>Very slightly acid</th>
<th>Very slightly alkaline</th>
<th>Slightly alkaline</th>
<th>Medium alkaline</th>
<th>Strongly alkaline</th>
</tr>
</thead>
</table>

- nitrogen
- phosphorus
- potassium
- sulphur
- calcium
- magnesium
- iron
- manganese
- boron
- copper & zinc
- molybdenum
Soil pH

Red = acidic soil.
Yellow = neutral soil.
Blue = alkaline soil.

https://en.wikipedia.org/wiki/Soil_pH
Soil pH influence and P availability

- P fixation by iron (Fe)
- P fixation by aluminium (Al)
- P precipitation by calcium (Ca)

Range of maximum P availability

http://crystalgreen.com/agriculture/
Improving soybean for production under P limited conditions

- Identification of superior phenotypes (MO)
- Testing under field conditions (A)
- Screening protocols that correlate to field performance (MO)
- Quantification and trade-offs and interacting effects for various adaptive traits (A)
- Generate & evaluate phenotypes and management strategies (A)
- Identification of QTLs (A, MO)
- Identification of genes (A, MO)
- Marker-assisted selection (A)
Identification of superior phenotypes

- **Improve P acquisition - root characteristics**
  - Expanded root surface area
  - Root length density
  - Root hairs
  - Organic acid synthesis and exudation
  - Induction and secretion of acid phosphatases
  - Mycorrhizal associations

- **Conservative P use**
  - Increase P use efficiency
    - Decrease growth rate
    - Alter (C) metabolism
Experiments in MO and in Ethiopia with Abush

- **MO:**
  - P uptake in select genotypes under field conditions
  - Controlled pot experiments in the field

- **Jimma:**
  - Evaluation of selected genotypes with and w/o P
    - Genotypes with contrasting top-soil RA
    - Genotypes with contrasting shoot P concentration
Experiments in MO and in Ethiopia with Abush

- **MO:**
  - P uptake in select genotypes under field conditions

- R5 biomass
- P concentration

⇒ P acquisition
Root system architecture
- Distribution of roots in the soil
- Root length density
Experiments in MO and in Ethiopia with Abush

**MO**

- Controlled pot experiments in the field
Experiments in MO and in Ethiopia with Abush

- **Jimma:**
  - Evaluation of selected genotypes
    - A) -P Fertilizer
    - B) +P Fertilizer
  
  1) High root complexity
  2) Low root complexity (top-soil root architecture)
  3) High P concentration in above ground BM
  4) Low P concentration in above ground BM

- **Agronomic evaluation**
  - Leaf tissue samples for P concentration analyses
  - P accumulation in tissue
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