Pigeonpea water use efficiency under different cropping systems in Ghana and Mali

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Why “pigeonpea” - the multipurpose legume

- Soil improving potential
- Provision of food – adds diversity to diets
- Minimal labor input and “a woman’s crop”
- Drought resistance
- Source of income
- Extra growing season (helps to intensify system)
- High quality dry season feed source for animals
- Fuel-wood

**Ideal legume for intercropping**
- Tolerate wide environmental conditions and low soil fertility
- Initial slow growth which present little competition
- Hydraulic lift potential
- Uses residual moisture
- Improves water use efficiency due to the rapid canopy structure

However pigeonpea is not included in the cropping systems of Ghana and Mali
Introduction

- Majority of farmers in Ghana and Mali depend on rain-fed, subsistence systems.

- The rising water scarcity presents future threat to food production.

- Improving water use efficiency is a critical response to this growing water scarcity.

- Increasing crop yields will require the use of crops with deep rooting system and the potential of soil moisture extraction.

- Cropping systems and soil management strategies that optimize efficient resource use is needed to sustain agricultural production.
Questions

Which cultivar is water efficient?

Does the hydraulic lift of pigeonpea make the plant water use efficient?
Hypotheses

- We hypothesized that medium duration pigeonpea will have higher yields than long duration pigeonpea in intercropping systems.
- The WUE of cropping systems will be influenced by the growth habit (medium vs long duration) of pigeonpea cultivar and the interaction with seasonal rainfall patterns.

Objectives

- Determine the soil moisture distribution in the root zone of sorghum and pigeonpea.
- Assess the effect of cropping system on crop yield and water use efficiency.
Experiments were set-up in Ghana and Mali

- ICRISAT experimental station, Samanko (Mali)
- SARI station, Wa (Ghana)
- Two field sites were located in Samanko (low and high-P fields) and one in Wa

Map courtesy of: Brad Peter of department of Geography. MSU (2015)
Materials and Methods

**Experimental Design**
- RCBD, 4 replications
- 2 cultivars of pigeonpea (long and medium duration) and sorghum were planted as intercrop and sole crop during 2015 cropping season
- Intercrop system was an additive design

**Cropping systems**
- The experiment had 12 and 14 treatments but 5 were used for soil moisture monitoring
  1. Sole pigeonpea, medium duration (PPM)
  2. Sole pigeonpea, long duration (PPL)
  3. Sole sorghum (SG)
  4. Sorghum-pigeonpea intercrop, medium duration (SGPPM)
  5. Sorghum-pigeonpea intercrop, medium duration (SGPPL)

**Nutrient management**
- Low fertility- no fertilizer, only organic manure
- High fertility- organic manure + fertilizer
  - DAP at 100kg/ha
  - Urea at 50kg/ha
Access tube installation and soil moisture monitoring

- Access tubes were installed within rows of each plot to a depth of 100 cm in all treatments.

- One access tube installed per treatment plot.

- Soil moisture content was monitored at different stages of plant growth during the growing season.

- Soil water content was measured at incremental depths of 0-10 cm, 10-20 cm, 20-40 cm, 40-60 cm, 60-100 cm using the Time domain reflectometry (TDR) profile probe type PR2.
Aboveground biomass assessment

- Destructive samplings at vegetative, flowering and maturity

- Five whole plants per plot for sole crops and six for intercrops
Results (Low P)

Vegetative

Maturity

Volumetric water content (cm$^3$/cm$^3$)

Depth (cm)

Depth (cm)

- pigeonpea long
- pigeonpea medium
- sorghum
- sorghum-pigeonpea (long)
- sorghum-pigeonpea (medium)
Results (High P)

Vegetative

Maturity

Volumetric water content (cm²/cm³)

Depth (cm)

- pigeonpea long
- pigeonpea medium
- sorghum
- sorghum-pigeonpea (long)
- sorghum-pigeonpea (medium)
Results (Wa)

Flowering

Maturity

Volumetric water content (cm$^3$/cm$^3$)

Depth (cm)

Volumetric water content (cm$^3$/cm$^3$)

Depth (cm)

- Pigeonpea long
- Pigeonpea medium
- Sorghum
- Sorghum-pigeonpea (long)
- Sorghum-pigeonpea (medium)
WUE$_b$ under different cropping systems at physiological maturity
Conclusions

- Soil water content reduced as the crops reached maturity indicating more water extraction.

- Soil water content values were greater below 10-30 cm, an indication of water movement to deeper horizons.

- Fertilizer addition enhanced crop growth as well as crop water use resulting in higher WUE.
Conclusions

- Intercropped systems show higher water use but not significantly different from sole cropped systems

- Results not conclusive at this point

Next steps

- Another cropping season in June 2016
- Use APSIM to simulate soil water competition in a sorghum-pigeonpea cropping system
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