Isotopic Tracer Study of Hydraulic Transfer Between Native Woody Shrubs and Associated Annual Crops Under Dry Conditions in the Sahel

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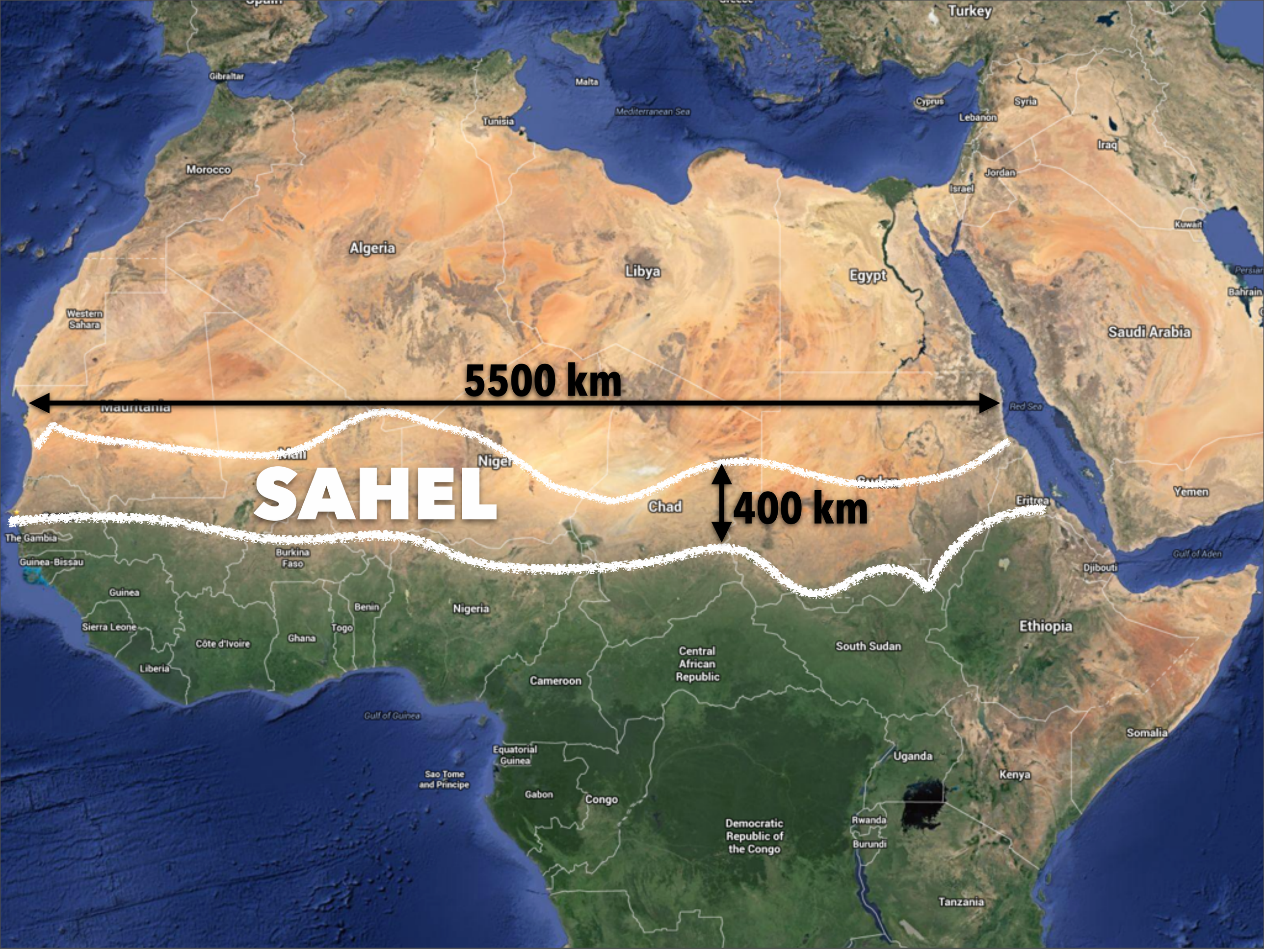
Thursday, April 16, 15



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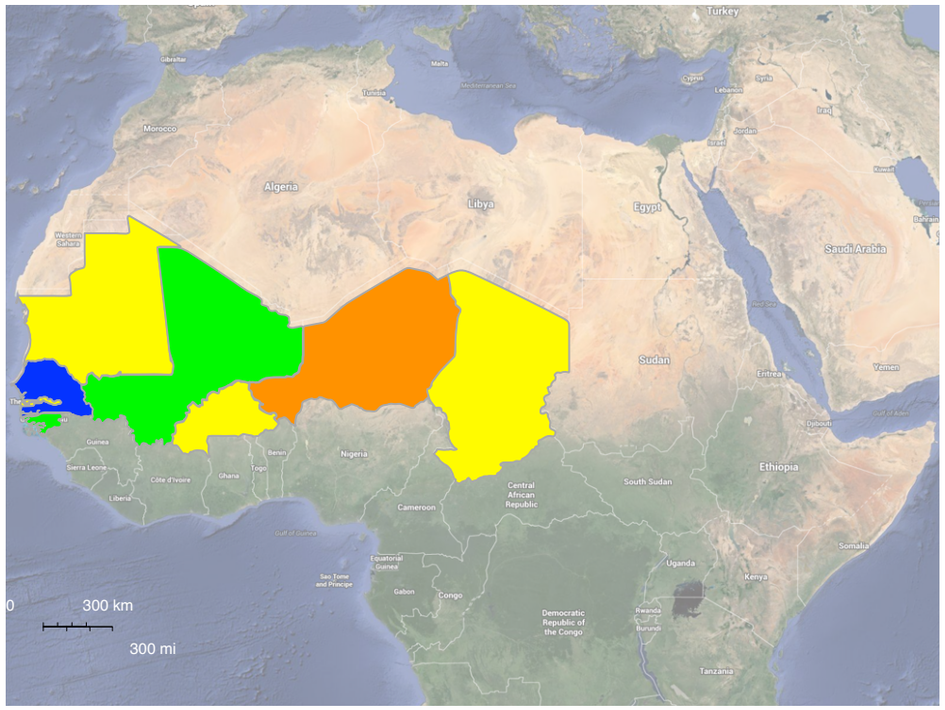
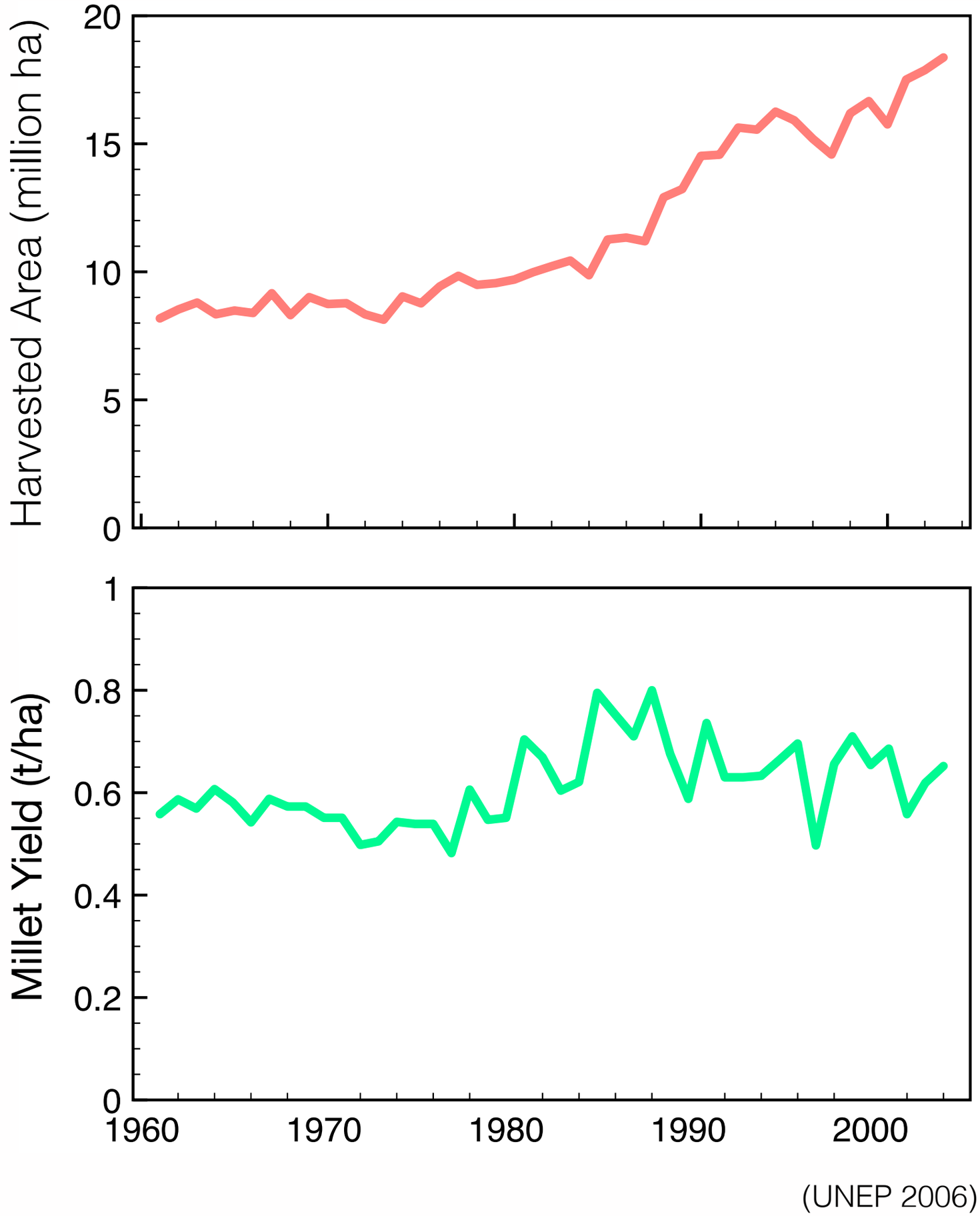
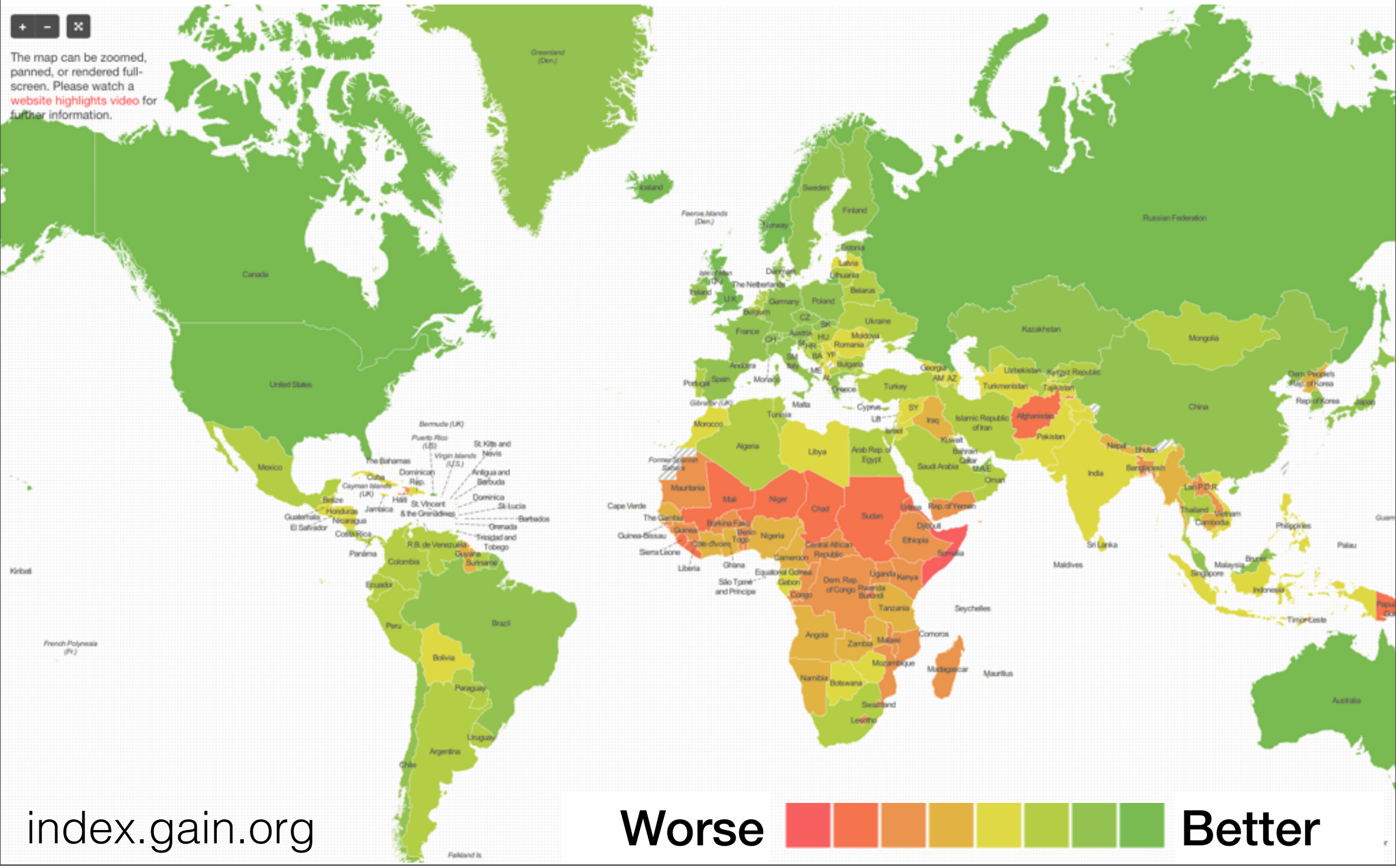

Turkey
Gibraltar
Malta
Tunisia
Mediterranean Sea
Cyprus
Syria
Lebanon
Iraq
Morocco
Jordan
Israel
Algeria
Libya
Egypt
Kuwait
Bahrain
Saudi Arabia
Western Sahara
Sudan
Eritrea
Yemen
Djibouti
Guinea
Benin
Nigeria
Sierra Leone
Côte d'Ivoire
Ghana
Togo
Liberia
Central African Republic
South Sudan
Ethiopia
Cameroon
Somalia
Equatorial Guinea
Uganda
Kenya
São Tomé and Príncipe
Gabon
Congo
Democratic Republic of the Congo
Rwanda
Burundi
Tanzania
0
300 km
300 mi


Harvested Area (million ha)
0
5
10
15
20
Millet Yield (t/ha)
0
0.2
0.4
0.6
0.8
1
1960
1970
1980
1990
2000

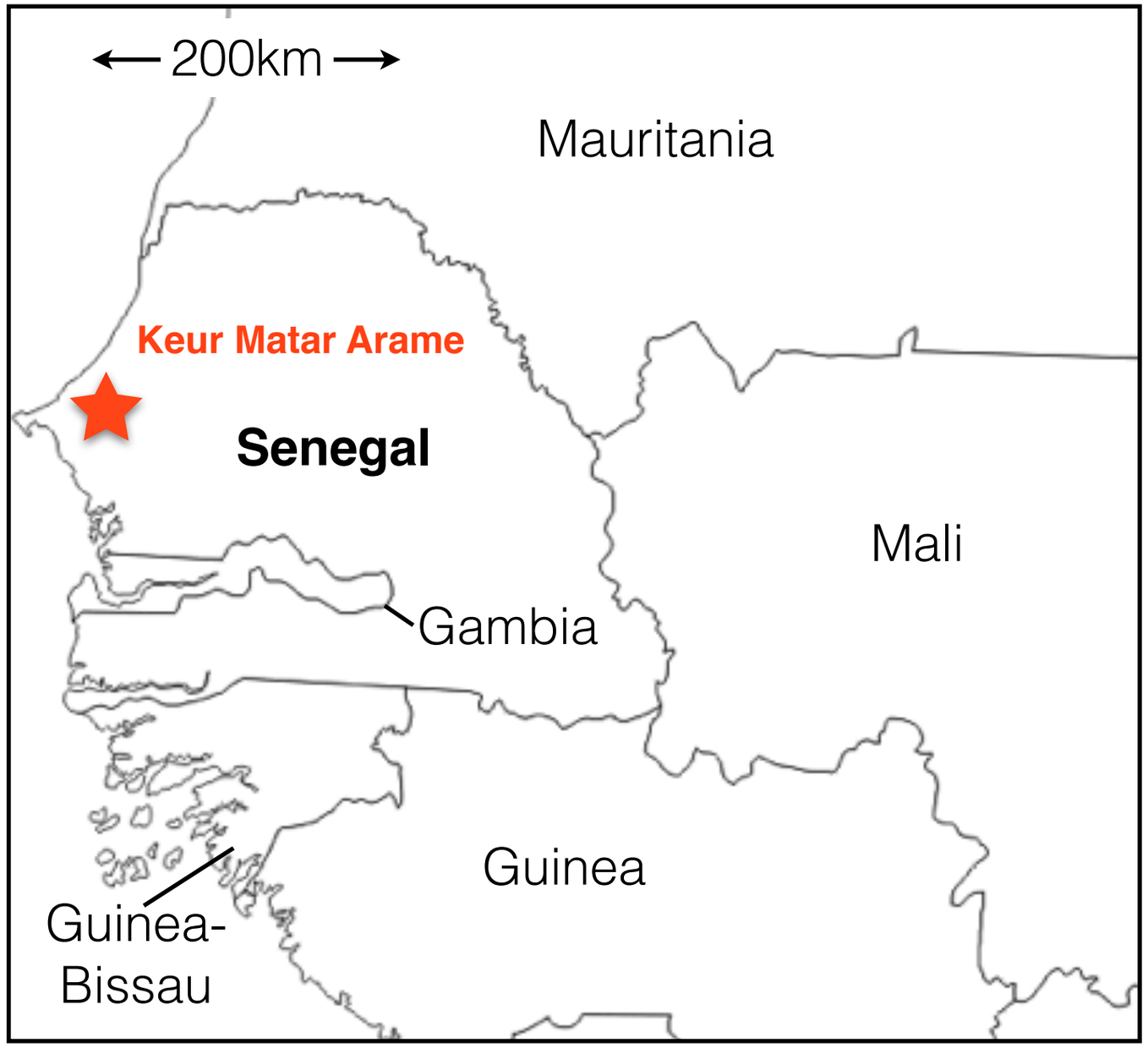
(UNEP 2006)

Vulnerability to Changing Climate



Field Site: Keur Matar Arame, Senegal

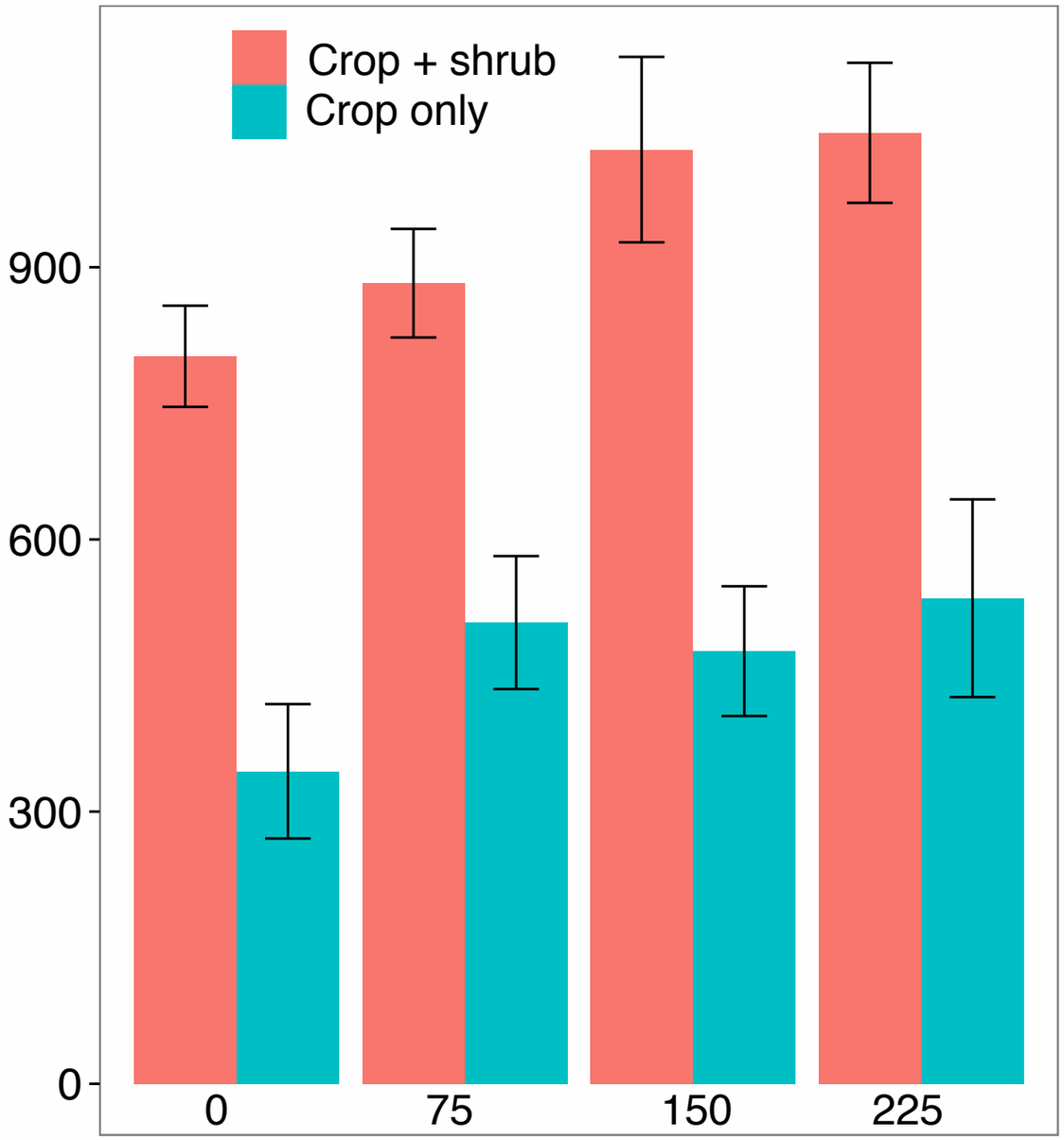
- Rainy season daytime temperatures up to 34°C
- Relative humidity is 60-90% during rainy season.
- Current agricultural model is rain-fed
- Limited use of fertilizer
- Nutrient poor sandy soils (arenosol)



Guiera senegalensis

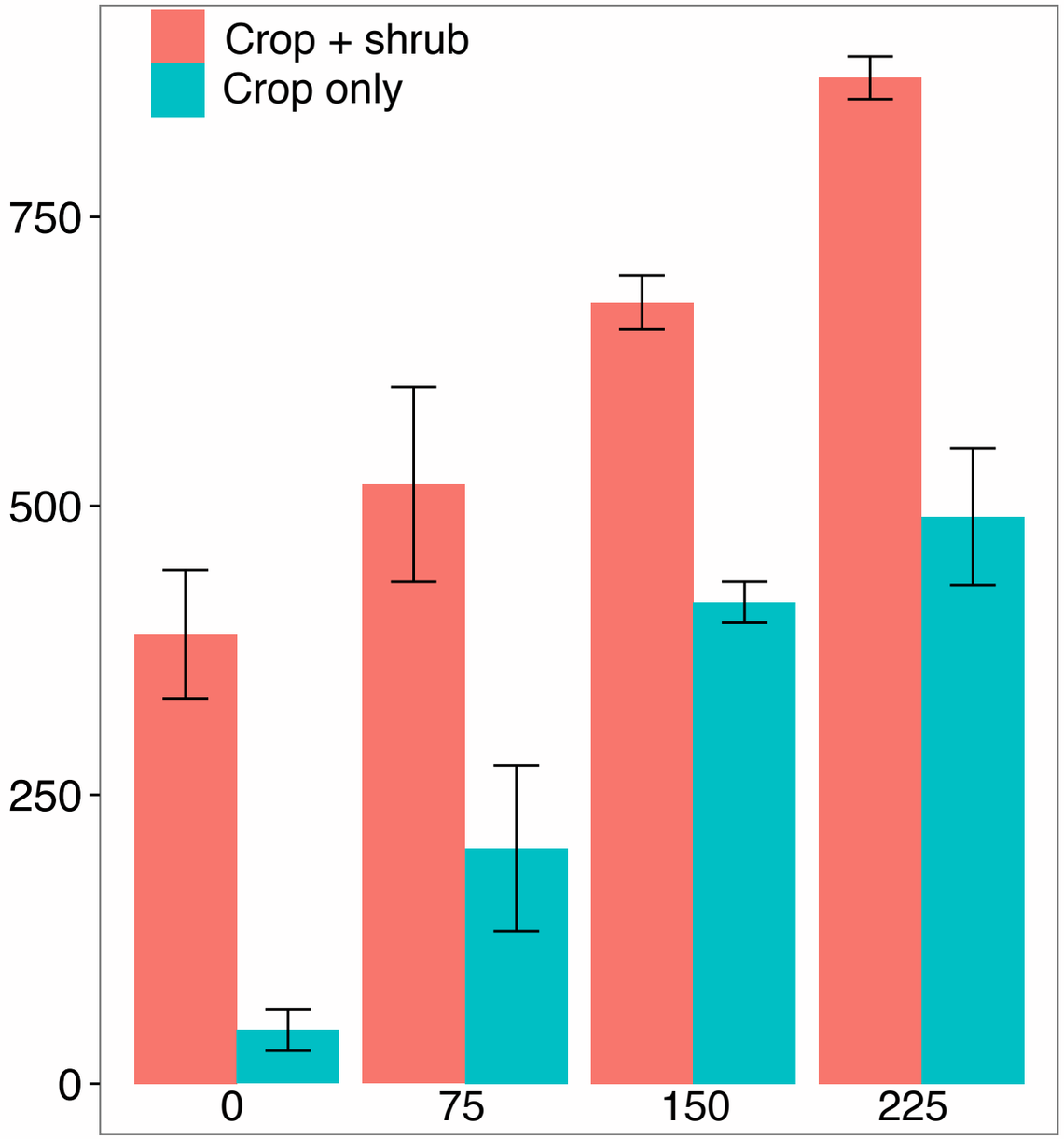
Deep tap roots help shrubs to survive long dry season

2012: PEANUT PODS (kg/ha)



NPK application rate kg ha^{-1}

2013: MILLET PANICLE (kg/ha)



NPK application rate kg ha^{-1}

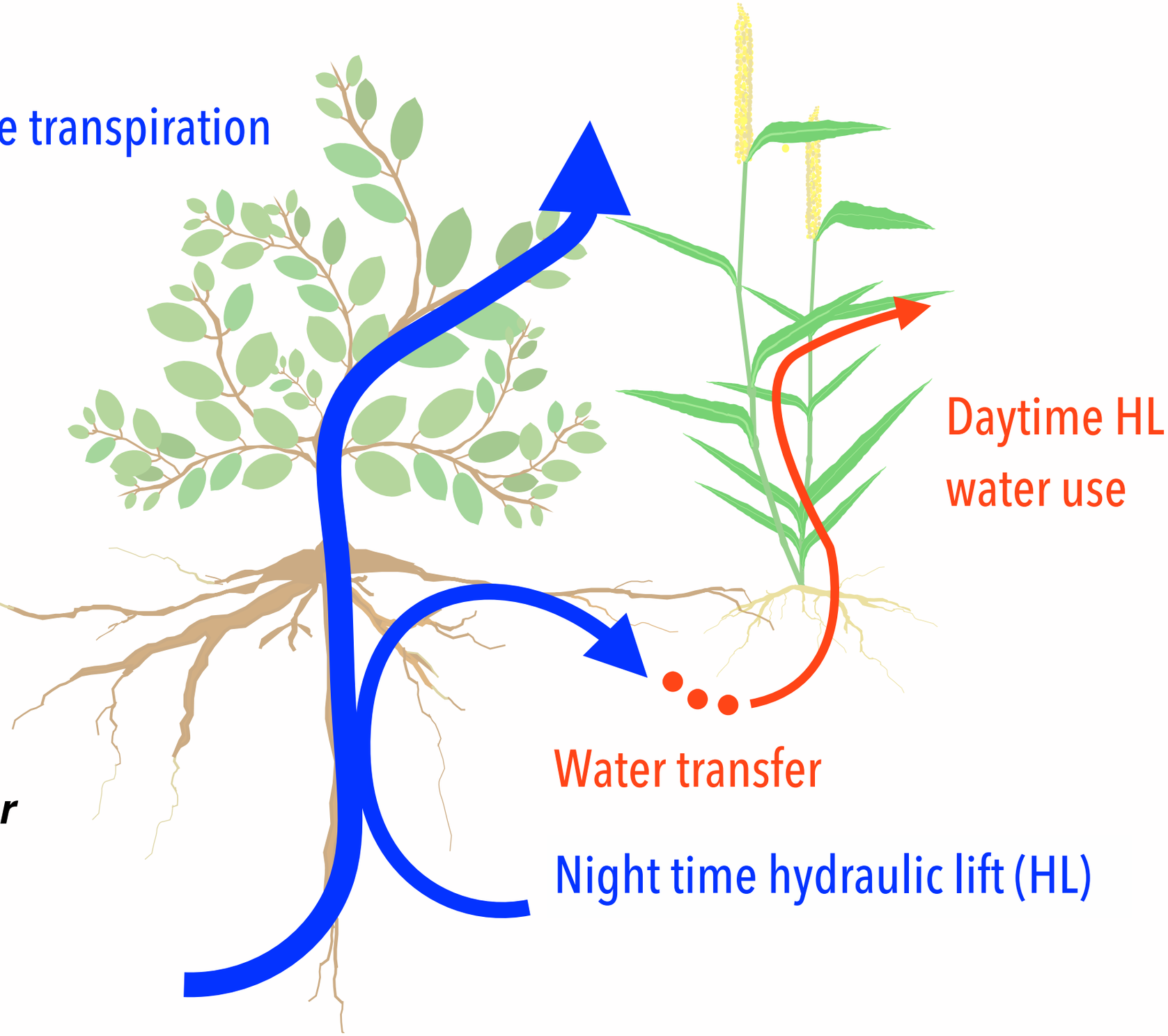
FROM MANAGED NSF RESEARCH PLOT IN KEUR MATAR ARAME (NORTH)

Previous Studies of Hydraulic lift and transfer

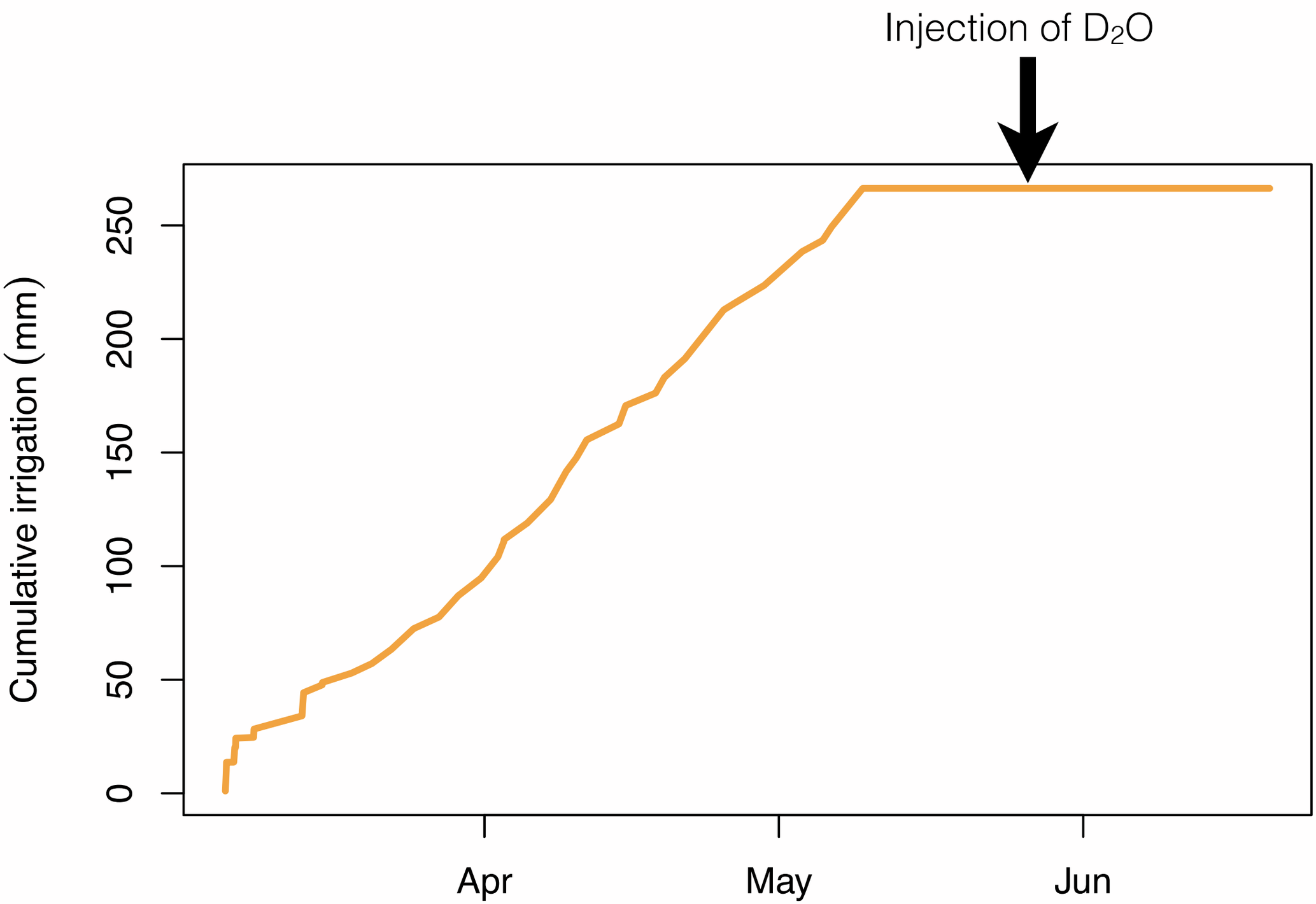
Plant to plant transfer
Caldwell and Richards, 1989
Filella, Penuelas 2003
Sekiya, Yano, 2004

Plant to mycorrhizae transfer
Querejeta et al. 2003
Warren et al. 2008

Hydraulic lift in G. senegalensis
Kizito et al. 2007



Irrigation-Water Stress Experiment



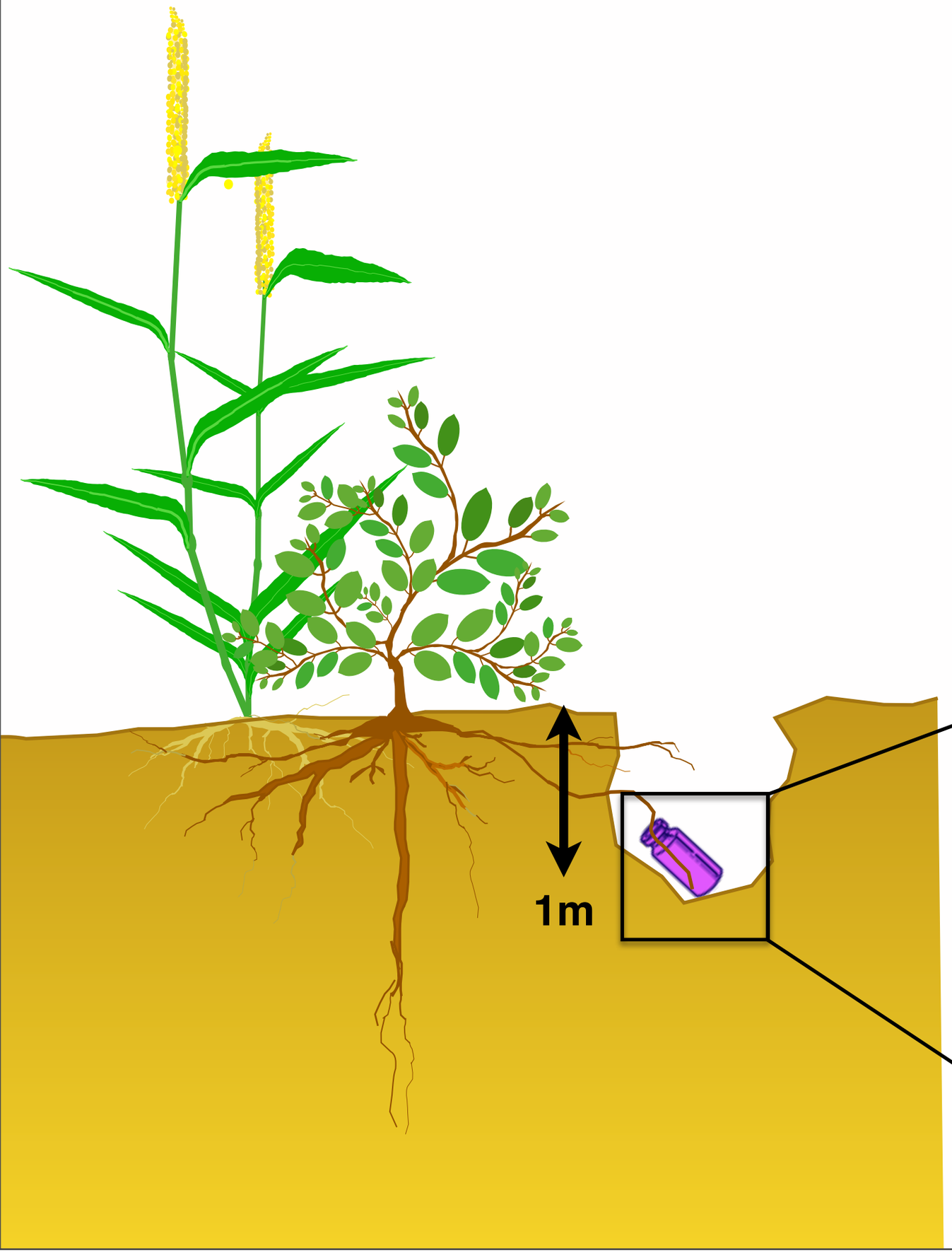
Stable Isotope Injection

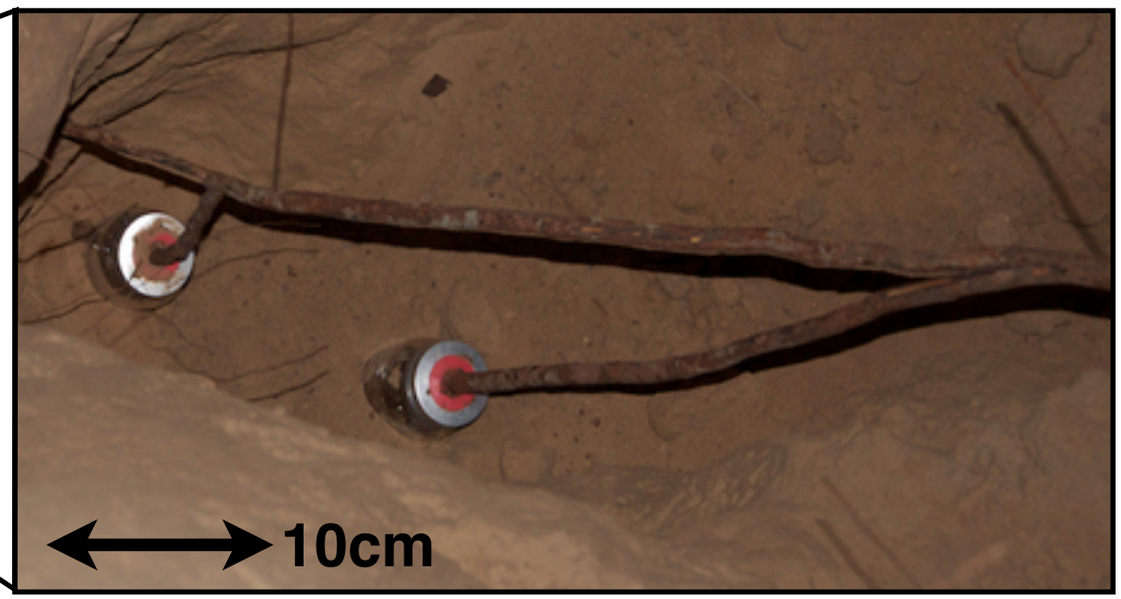
Two roots were identified for each shrub at depth of >1m.

Roots were severed and immersed into100 ml vial filled with deuterated water (46 atom %) and sealed

Injected after sunset, when transpiration was the lowest

Tissue samples were collected prior to injection and twice daily for two days, then once daily for additional 2 days





Sampling and water extraction

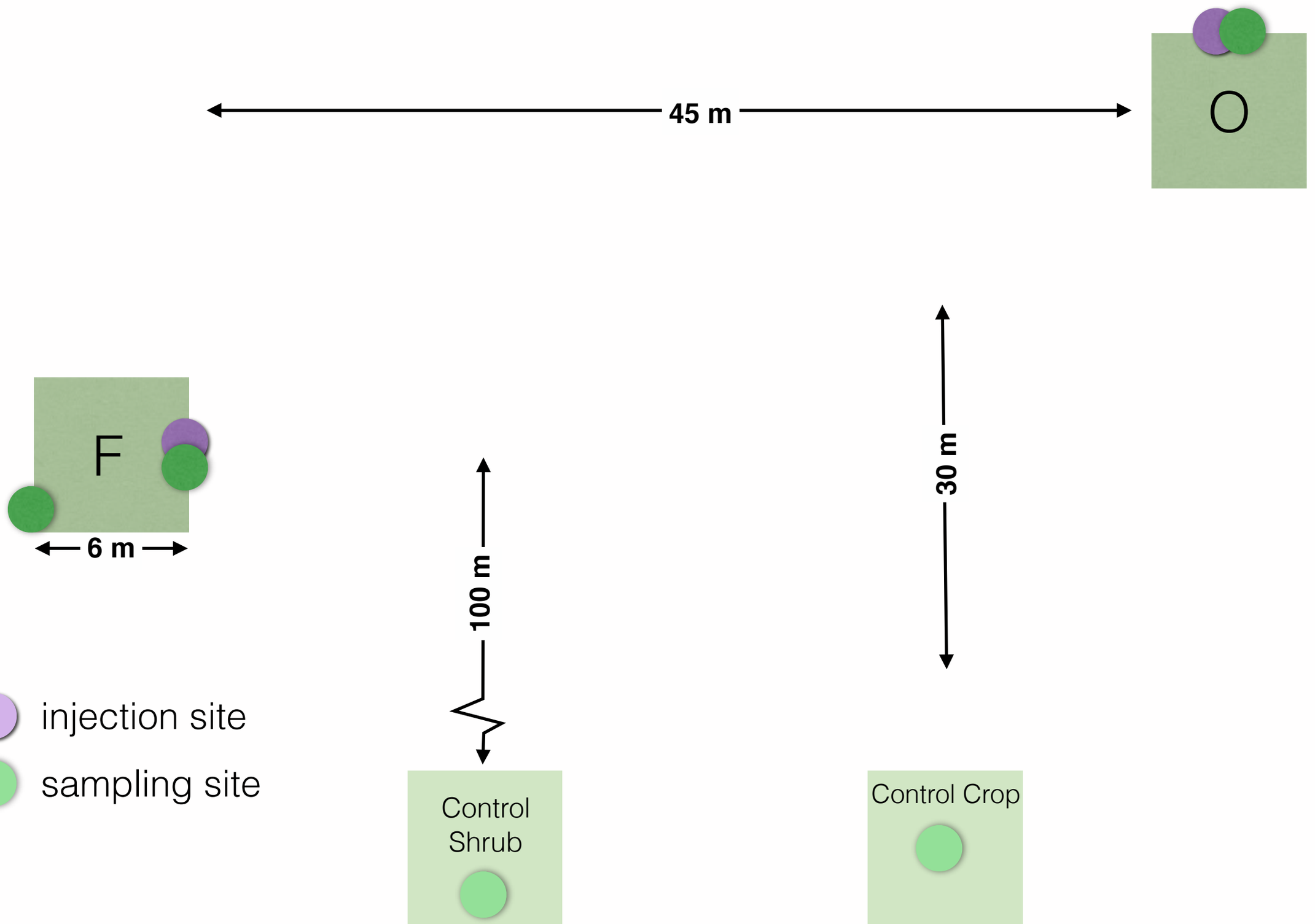
Sampling

- Samples: 3-5 pieces of guiera stem/millet tiller with outer bark/layers removed, sealed in glass vials and frozen immediately

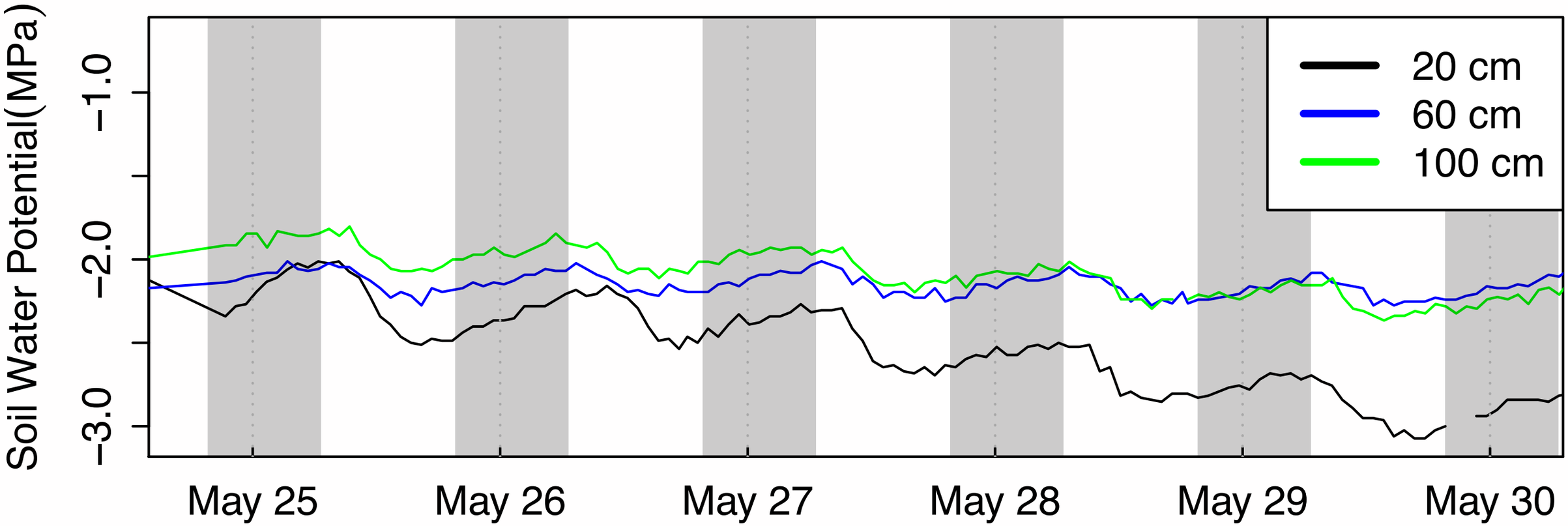
Water extracted by cryogenic vacuum distillation

- Samples frozen on liquid N and pumped down to 40-60mTorr
- If sample held vacuum then liquid nitrogen replaced with boiling water and sample extracted for minimum 90 minutes.
- Sample aliquot caught in liquid N, thawed, and pipetted into 2mL vial to run on mass spec.

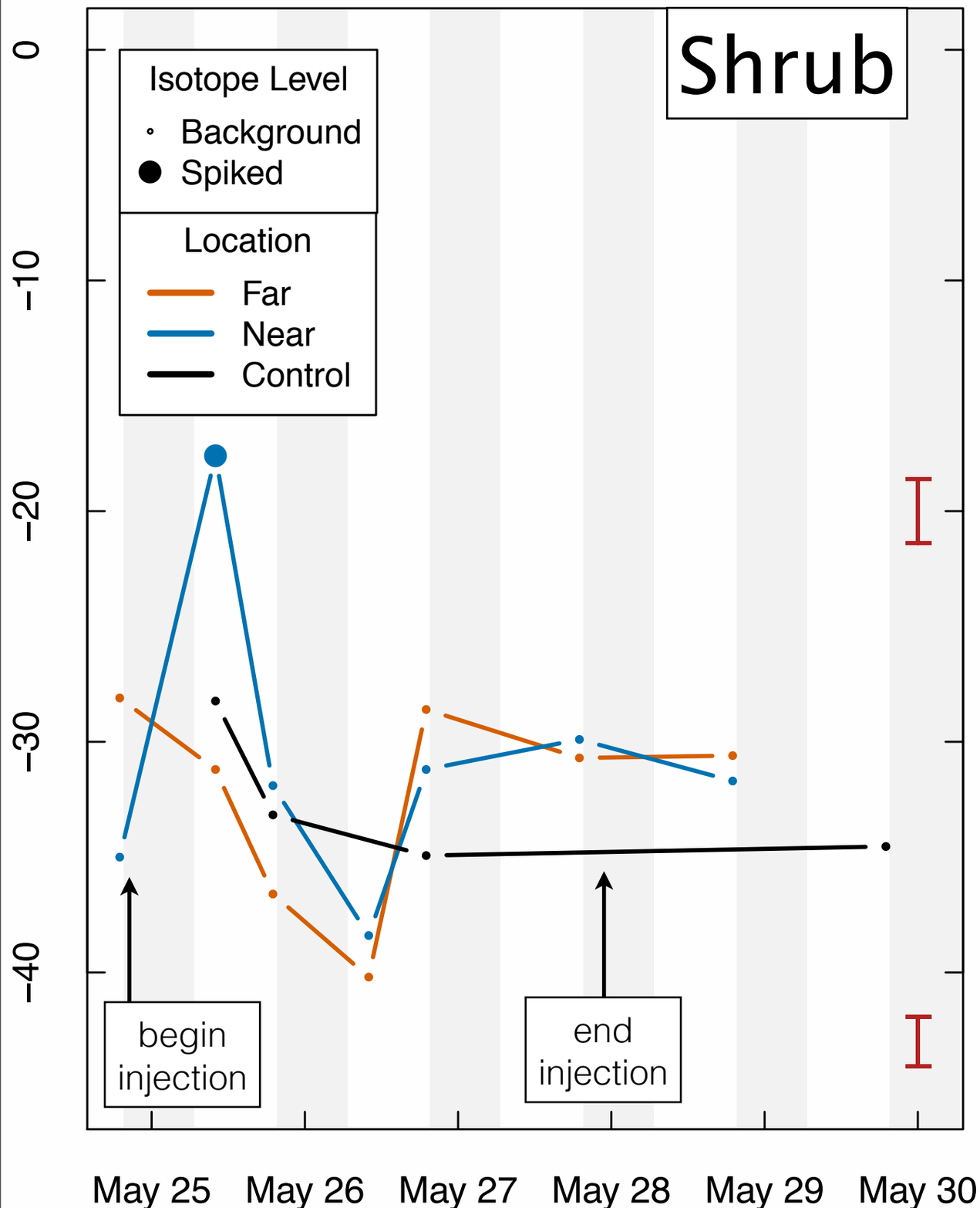
Layout of Field Plots

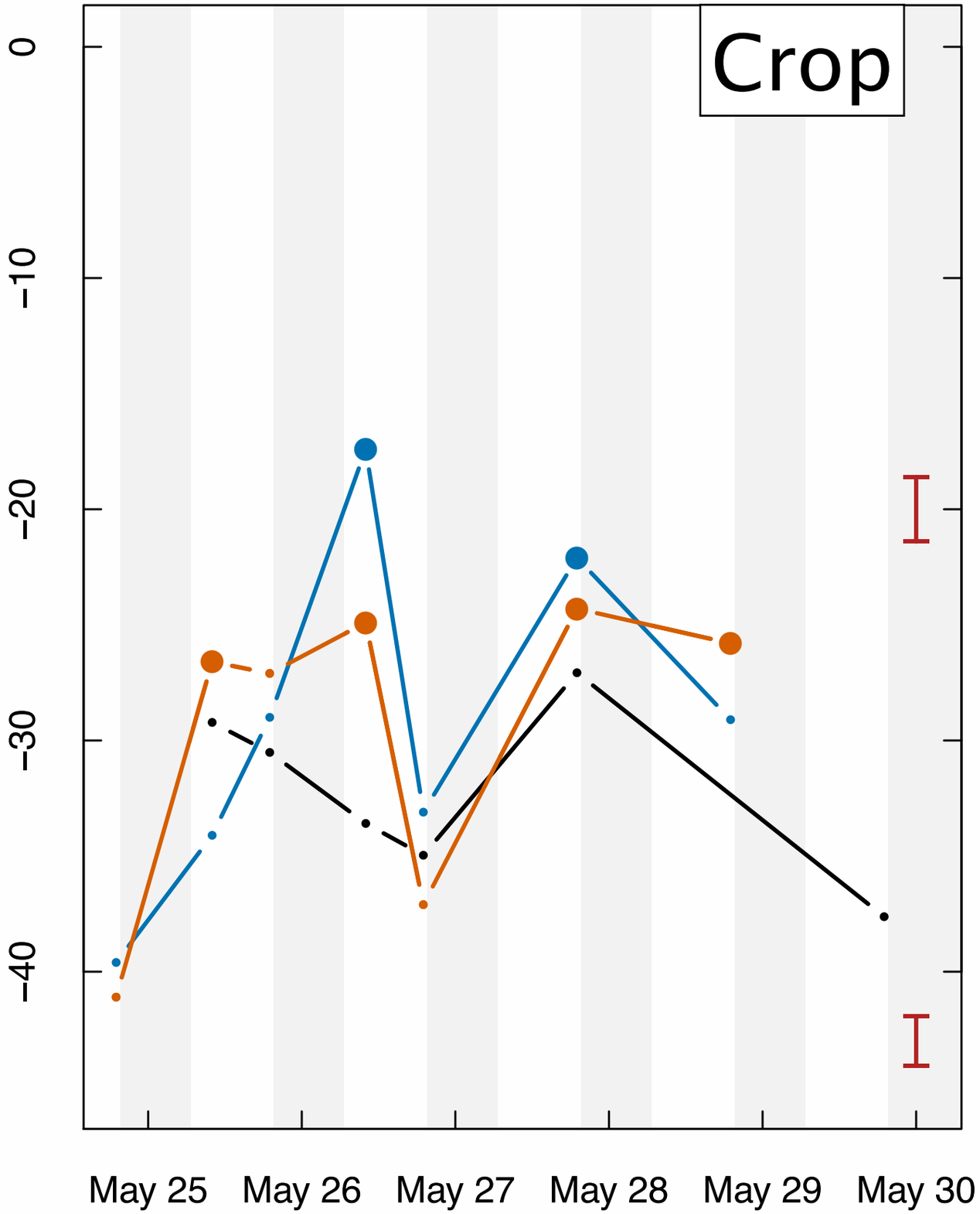


Soil water potential at three depths in plot “F”

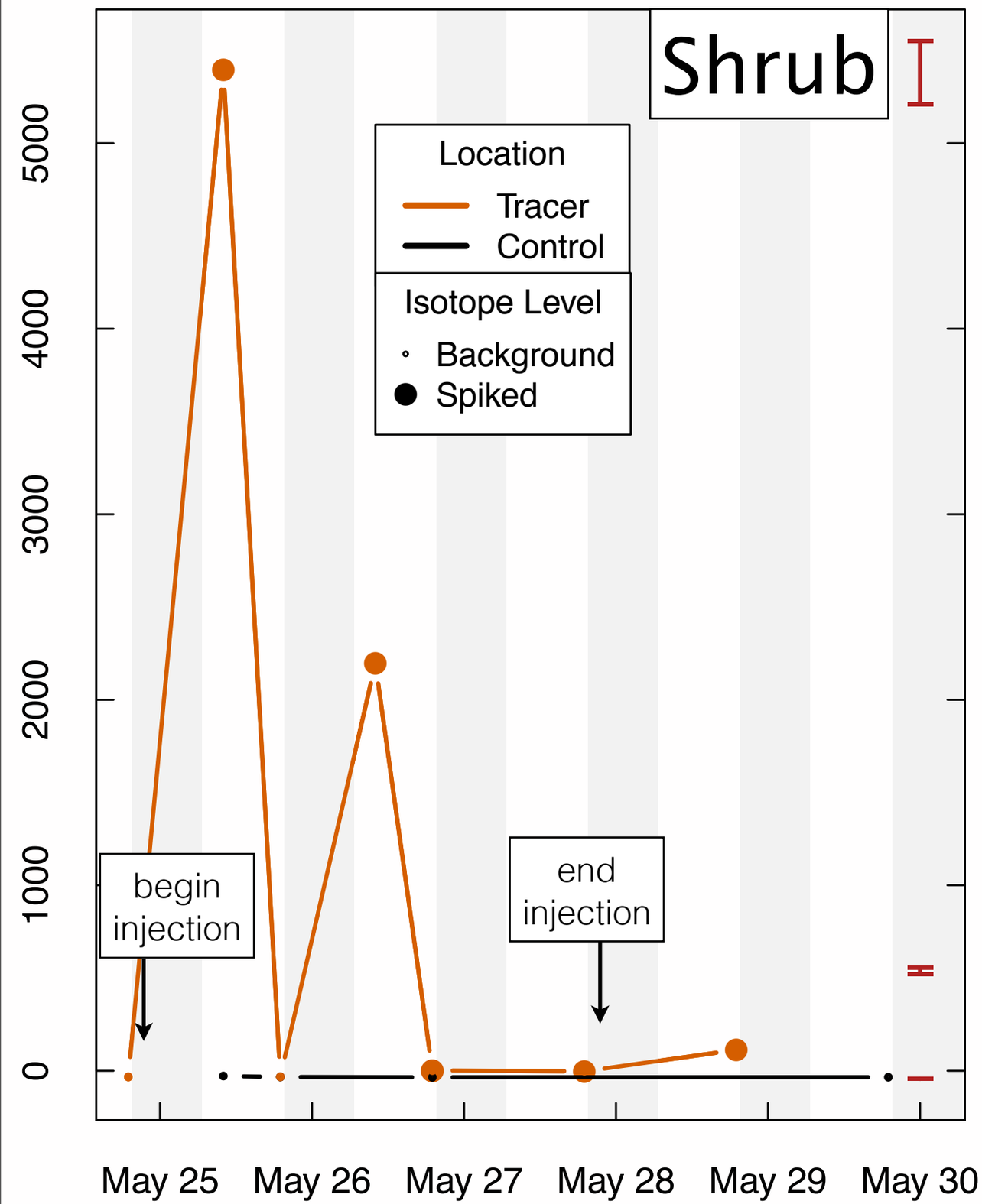


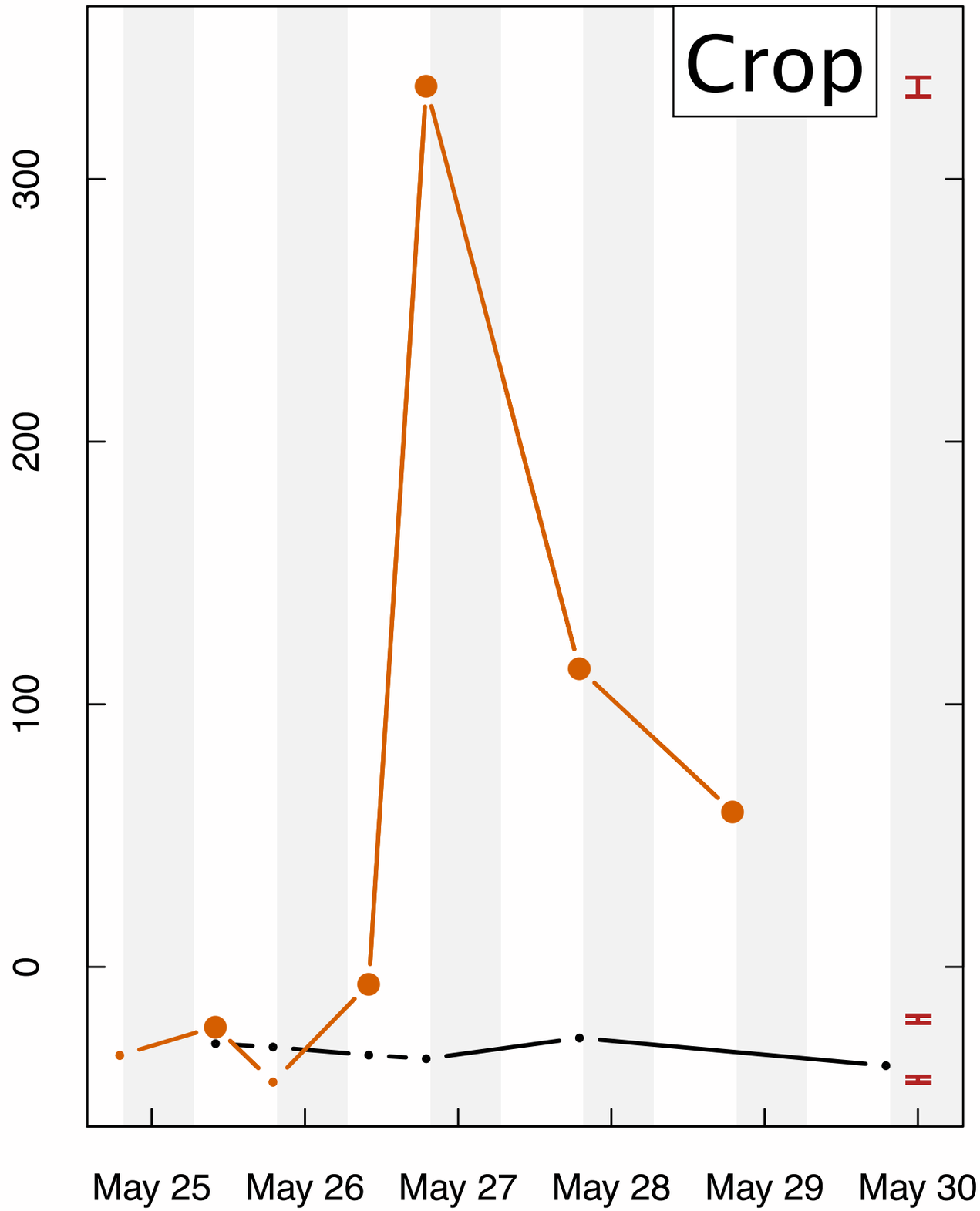
δD (VSMOW) at Plot “F”

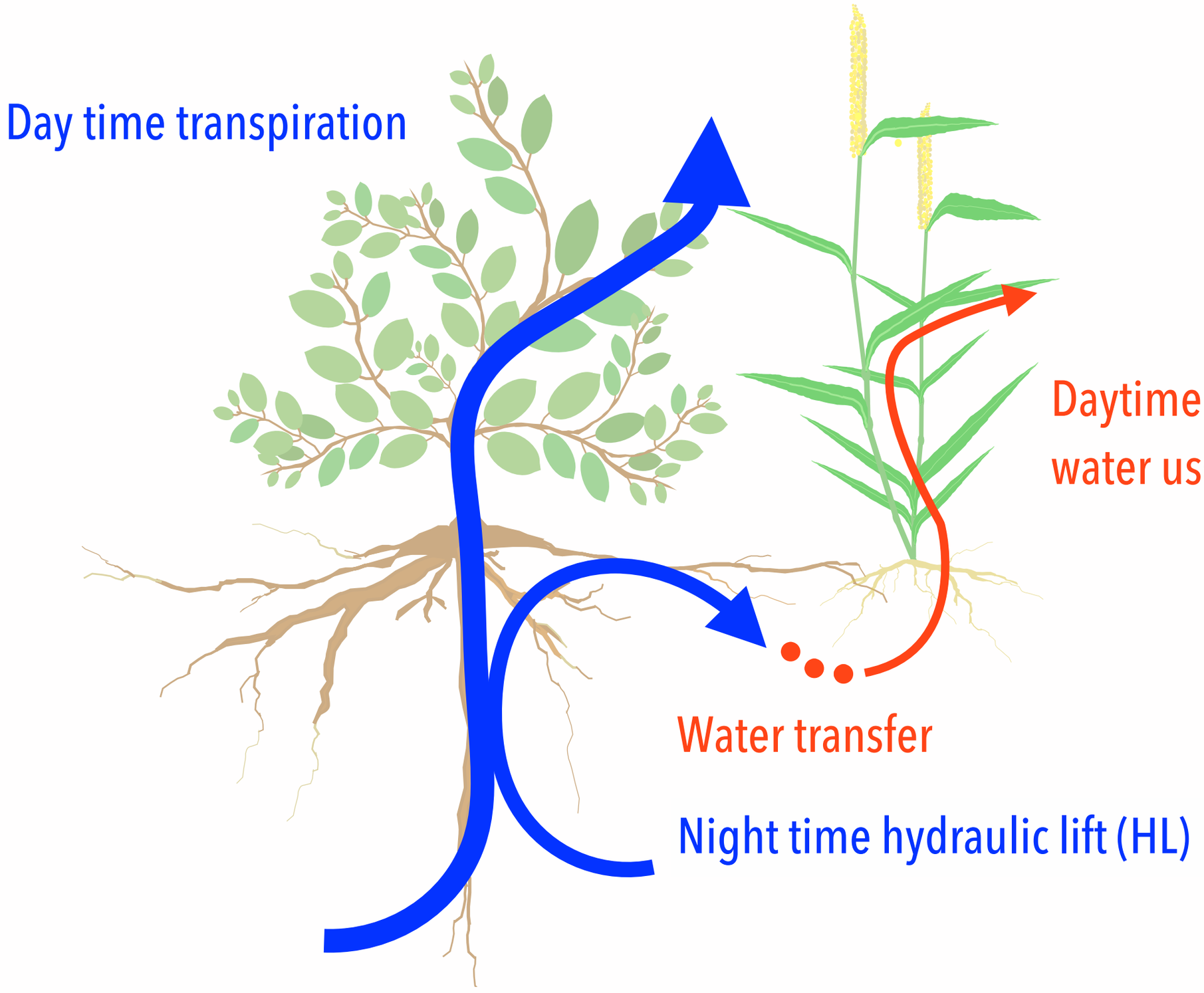




δD (VSMOW) at Plot "O"

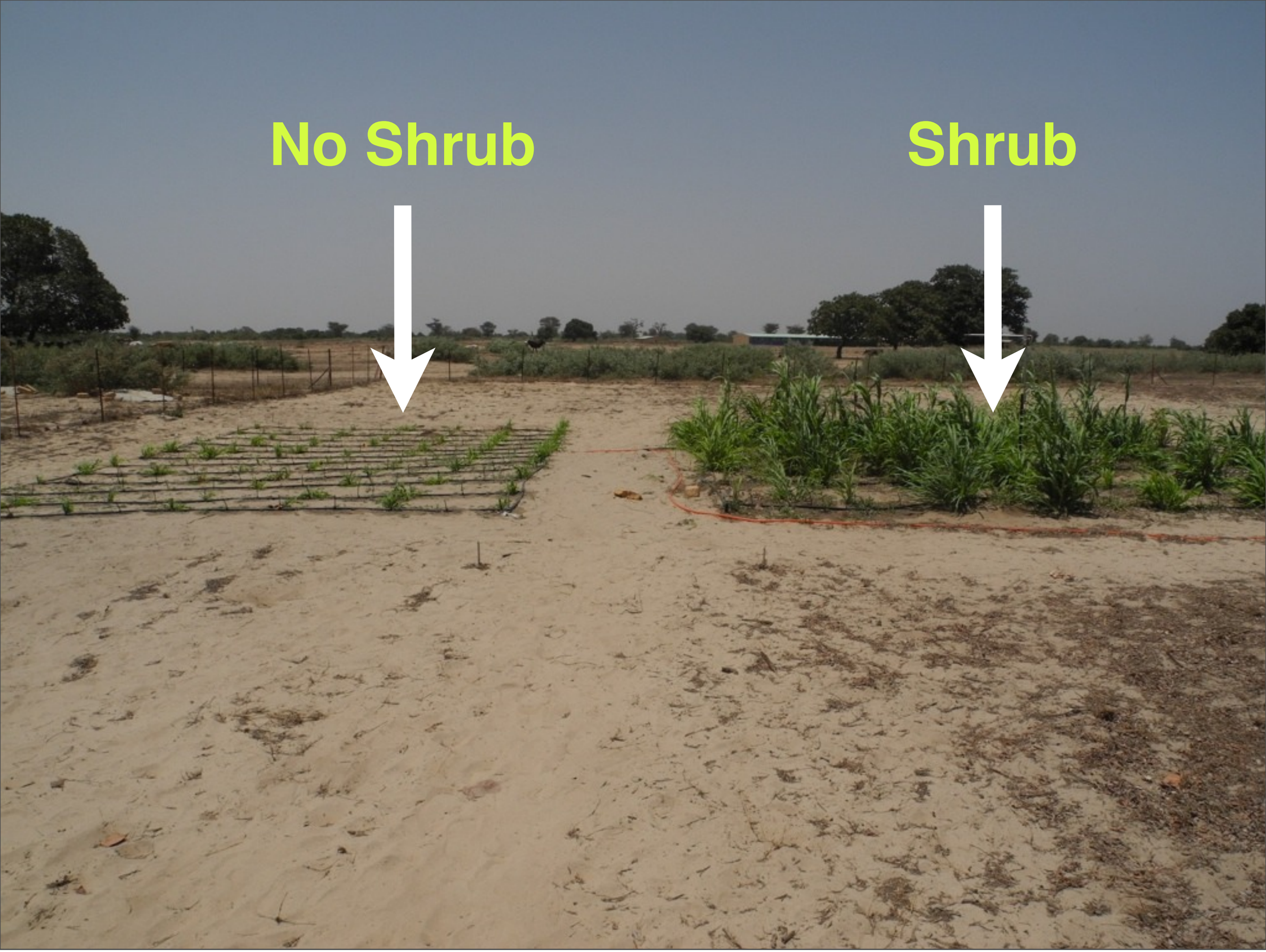





Day time transpiration
Daytime HL
water use
Water transfer
Night time hydraulic lift (HL)

Summary

- Two to five fold yield increase in crop yields as a result of intercropping.
- Yield differences are large even in times of drought stress when competition can outweigh benefit in other agroforestry systems.
- Evidence of hydraulic transfer between deep shrub roots and shallow-rooted millet plants.
- *Guiera senegalensis* habitat covers wide swaths of Sahel and could impart a significant impact on crop yields in the region.



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Thank You

Moussa Dionne
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Boubacar Badji
Mame Balla Ndiaye
Matthew Bright
Thies Field Technicians

NSF PIRE Senegal Grant