



Breeding perennial grains--a promising strategy for developing new deep-rooted crop species



Tim Crews
The Land Institute
Salina, Kansas





Photo: Jim Richardson



Two pathways to a perennial grain



PR23 Rice—wide hybridization



Kernza®-- domestication



Perennial wheat

Thinopyrum spp. X *Triticum* spp.



Perennial sorghum

Sorghum bicolor X *Sorghum halepense*

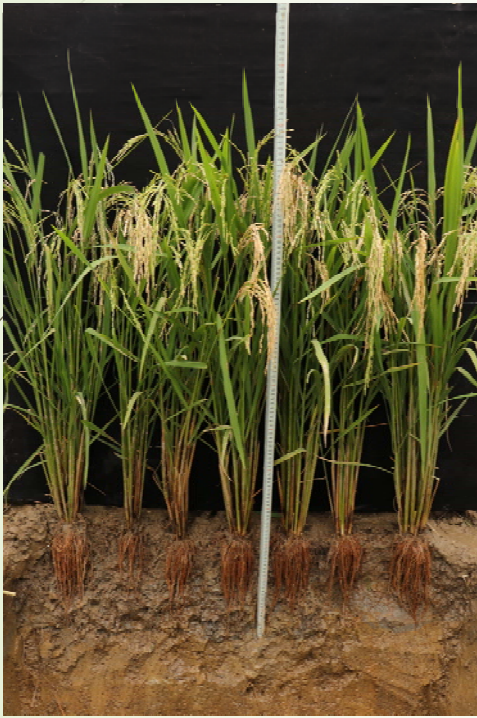


Perennial rice-- *Oryza sativa* X *Oryza longistaminata*

Wide hybridization
annual crop x perennial relative



Perennial Rice—Yunnan University

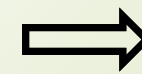


Annual rice
Oryza sativa

X

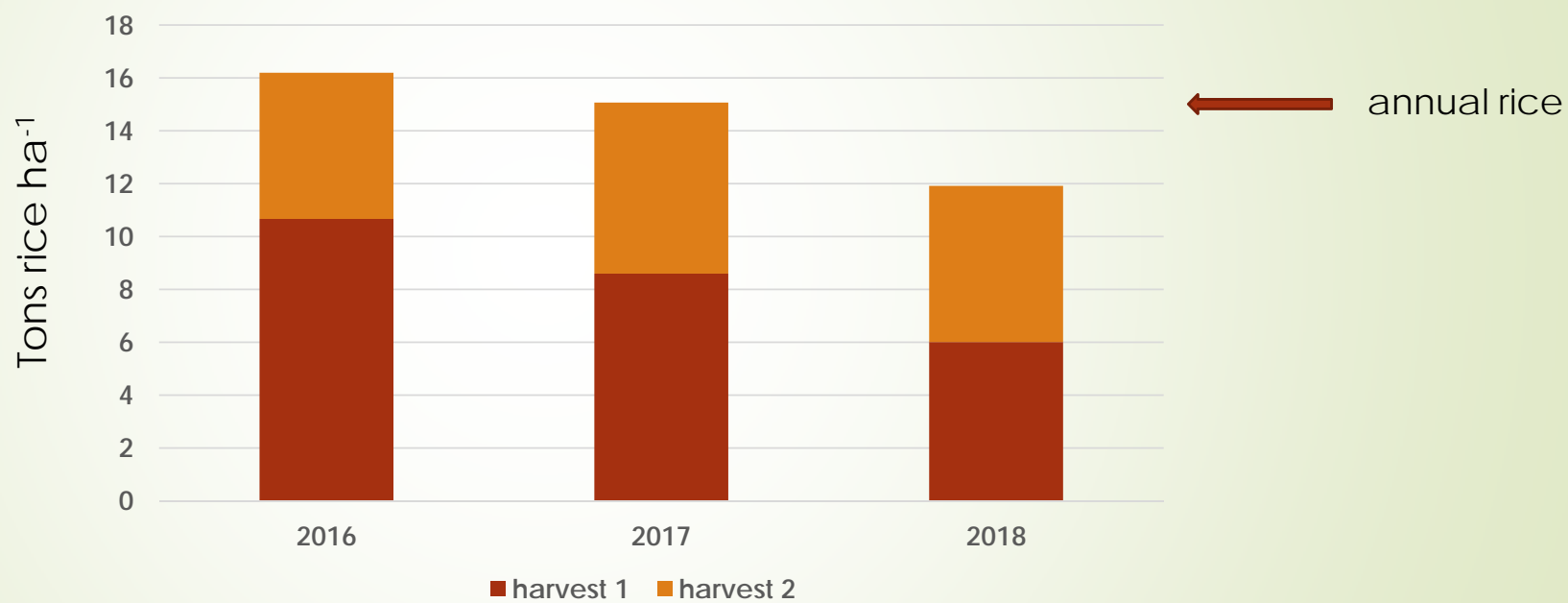


Perennial relative of rice
Oryza longistaminata



Perennial rice hybrid

PR23 Mengzhe Yunnan Province



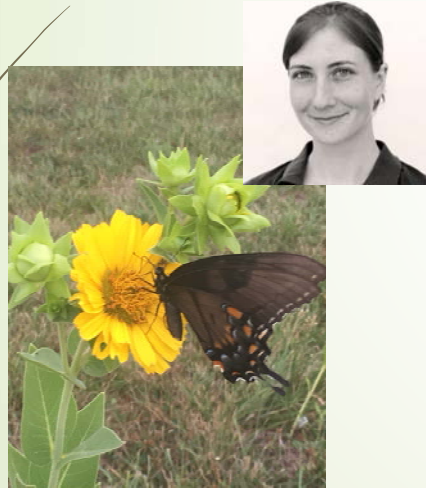
Hu, unpublished data



Perennial sorghum
rhizome

de novo Domestication

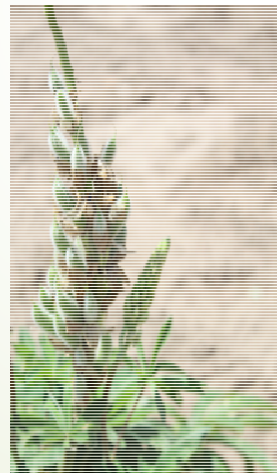
Oilseeds



Silphium

Silphium integrifolium

Legumes



Lupinus polyphyllus



Medicago spp.

Wheatgrass



Kernza

Thinopyrum intermedium



Helianthus annuus

Wild

Domestic





Helianthus annuus

Wild

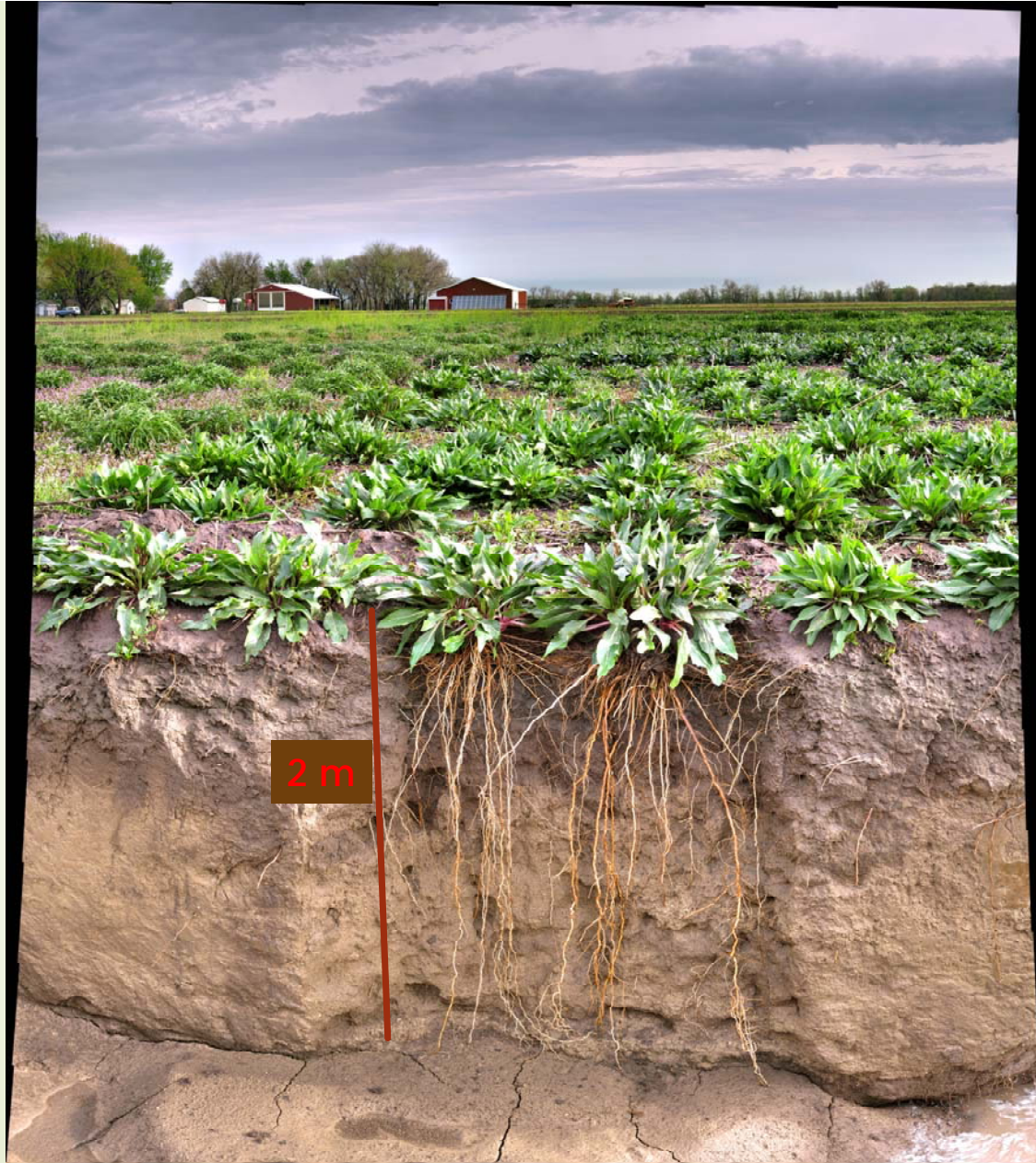
Domestic

Silphium integrifolium

H. maximiliani

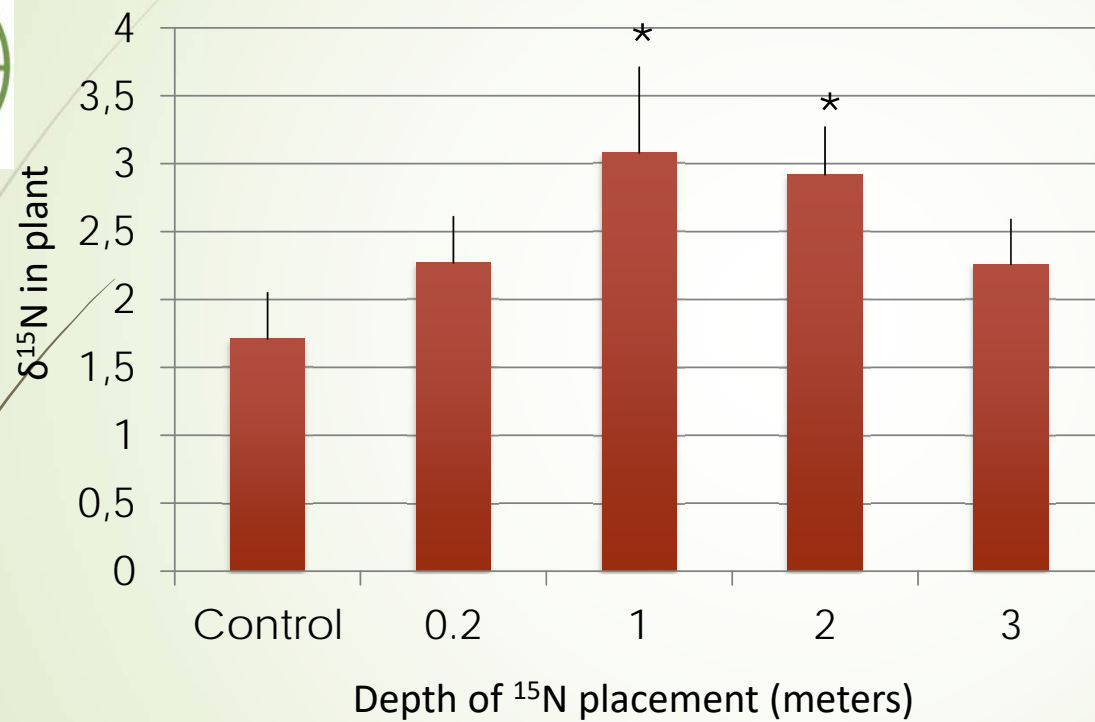








Depth of nitrogen uptake by *Silphium integrifolium*



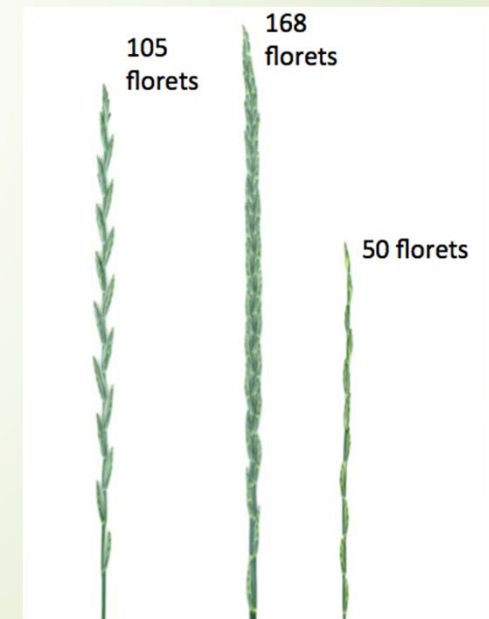
* Significantly different from control, one-tailed t-test, $p < 0.05$





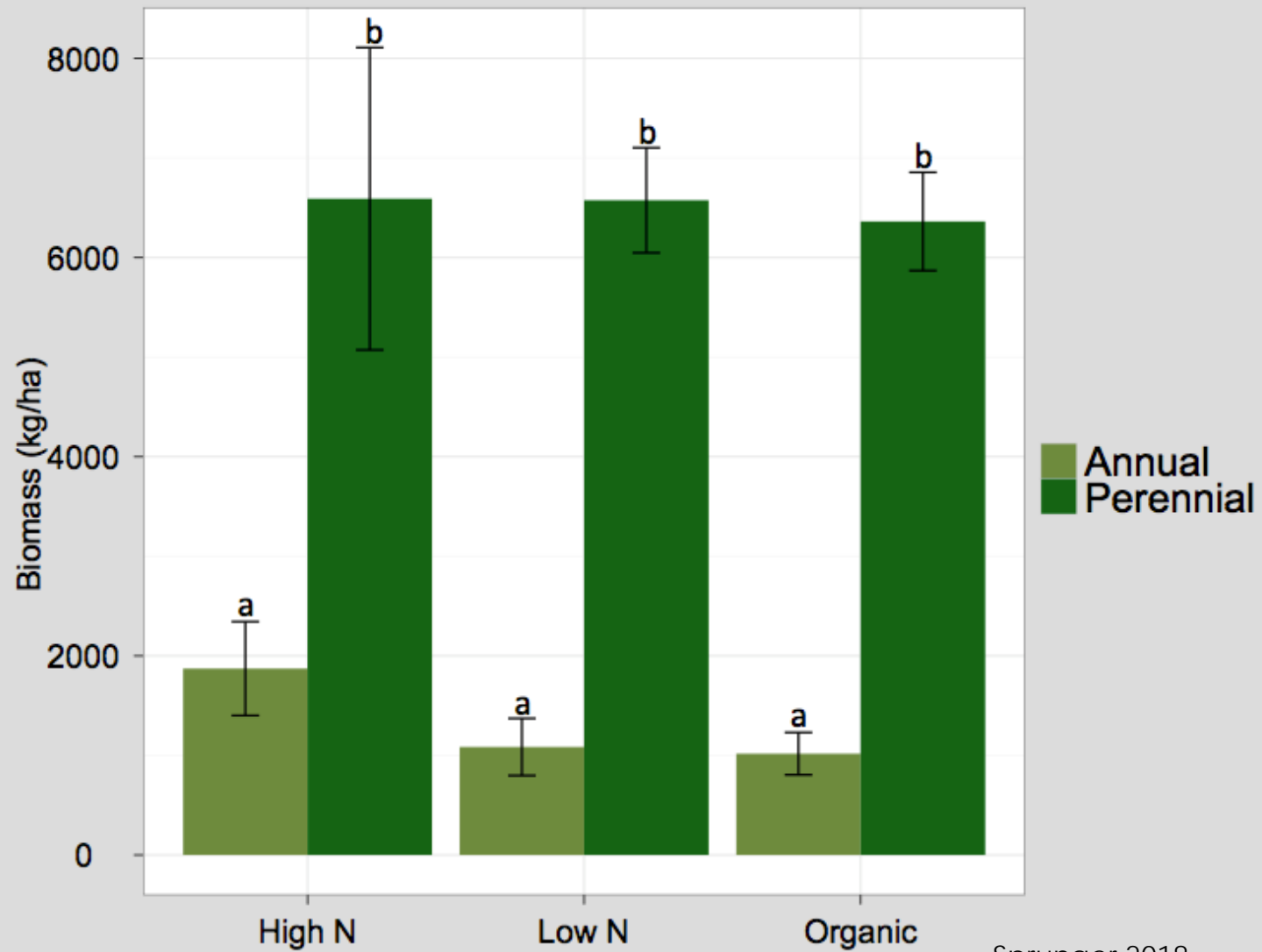
Intermediate Wheatgrass
Or “Kernza®” breeding nursery

DOMESTICATION





Total Root Biomass of annual wheat and perennial Kernza

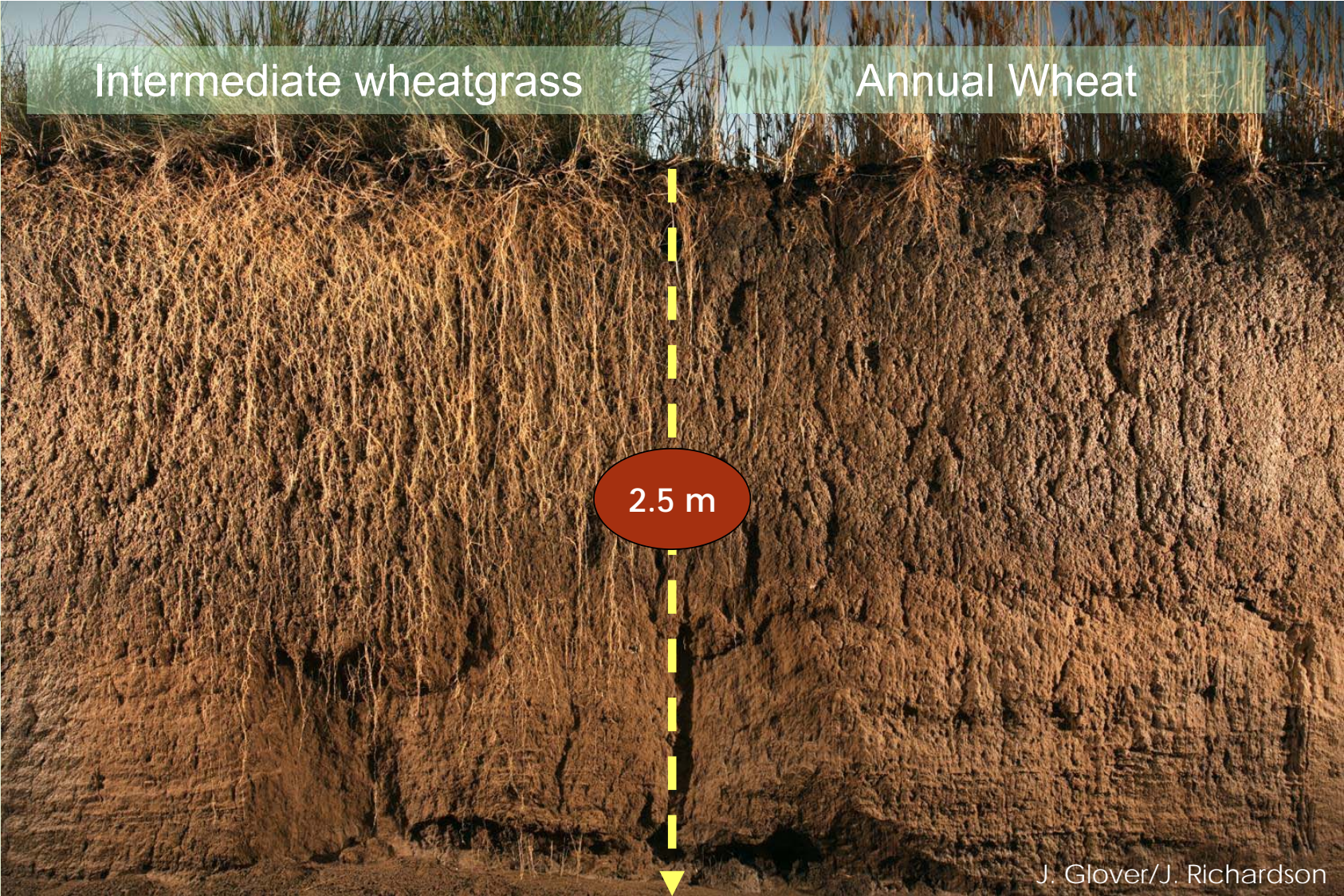


Intermediate wheatgrass

Annual Wheat

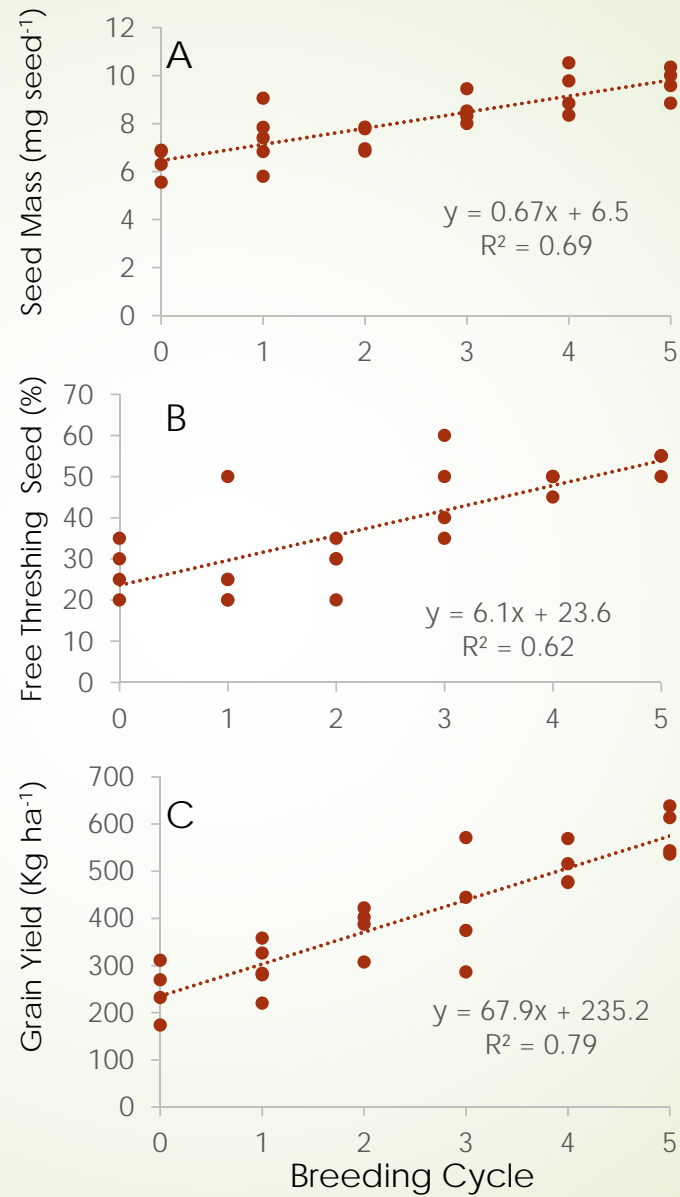
2.5 m

J. Glover/J. Richardson





Improvements in Kernza seed and Yield characteristics over five breeding cycles



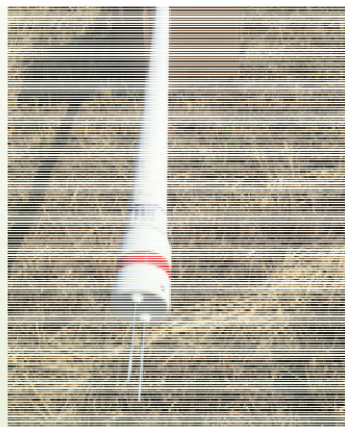
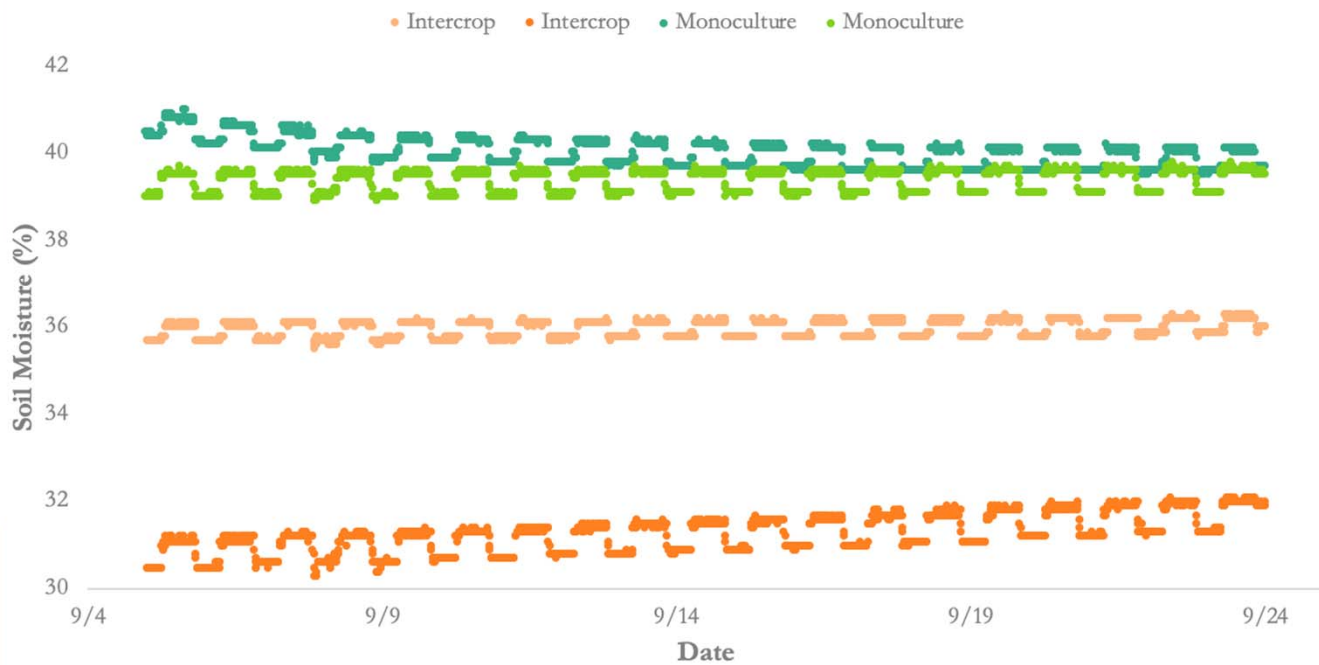
wheat

Kernza

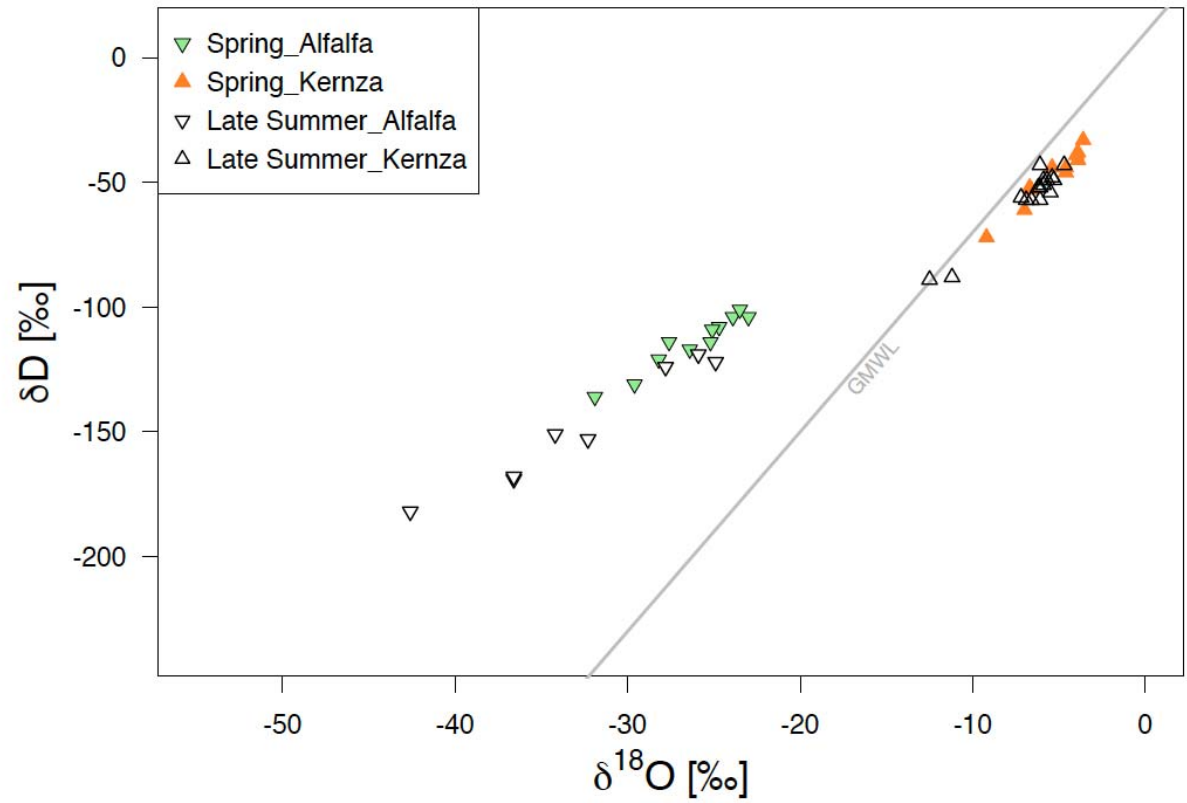




Soil Moisture in Kernza-Alfalfa Intercrop and Kernza Monoculture at 3m depth



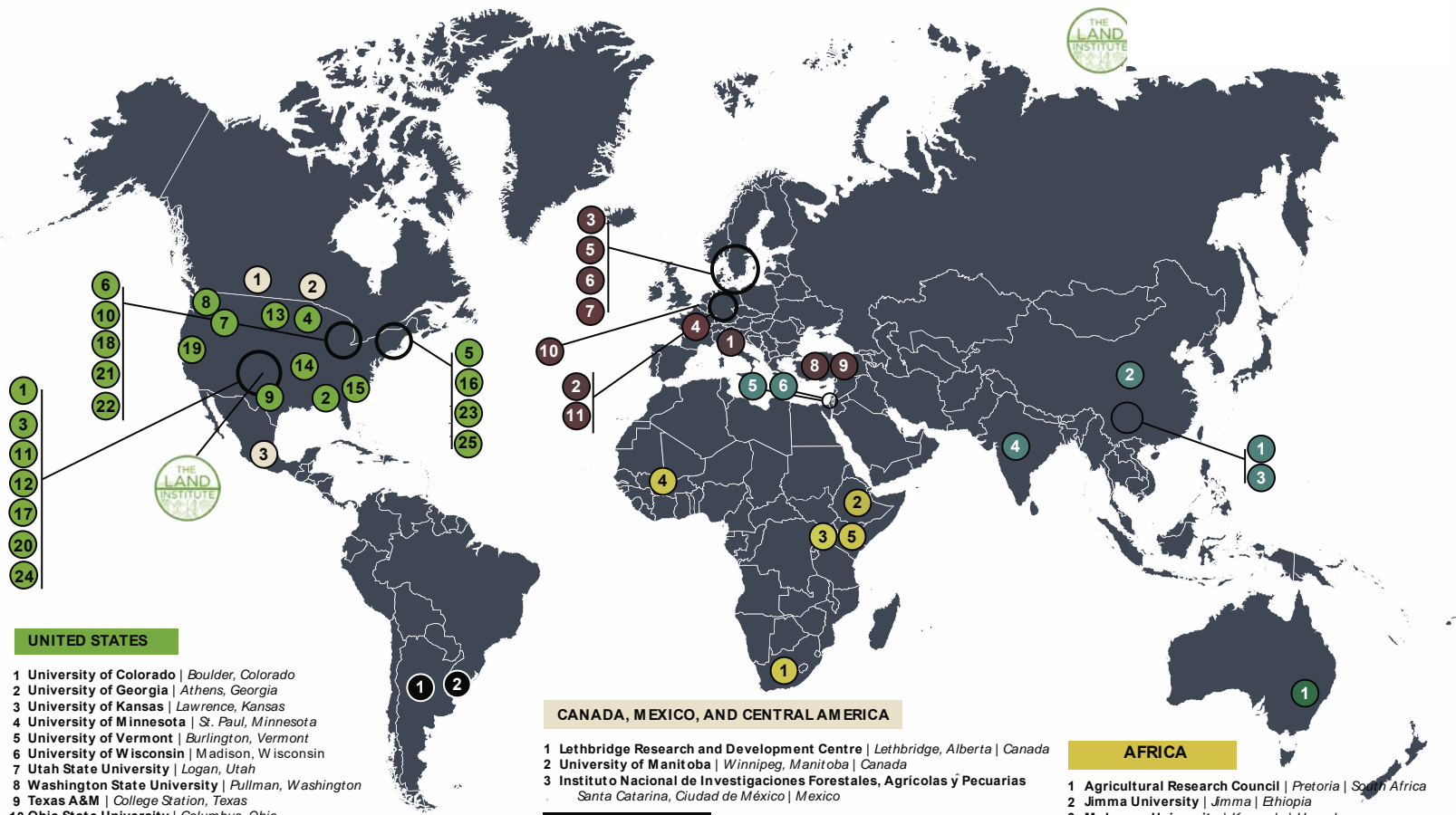
DuBois & Crews unpublished



Nosshi (2019)



Global Partners



UNITED STATES

- 1 University of Colorado | Boulder, Colorado
- 2 University of Georgia | Athens, Georgia
- 3 University of Kansas | Lawrence, Kansas
- 4 University of Minnesota | St. Paul, Minnesota
- 5 University of Vermont | Burlington, Vermont
- 6 University of Wisconsin | Madison, Wisconsin
- 7 Utah State University | Logan, Utah
- 8 Washington State University | Pullman, Washington
- 9 Texas A&M | College Station, Texas
- 10 Ohio State University | Columbus, Ohio
- 11 Oklahoma State University | Stillwater, Oklahoma
- 12 Perennial Agricultural Project Field Station | Lawrence, Kansas
- 13 Red River Valley Center – USDA-ARS | Fargo, North Dakota
- 14 St. Louis University and Missouri Botanical Garden & Danforth Center | St. Louis, Missouri
- 15 North Carolina State University | Kannapolis, North Carolina
- 16 Cornell University | Ithaca, New York
- 17 Kansas State University | Manhattan, Kansas
- 18 Michigan State University | East Lansing, Michigan
- 19 University of California, Davis | Davis, California
- 20 Colorado State University | Fort Collins, Colorado
- 21 Chicago Botanic Garden, Northwestern & Loyola University | Chicago, Illinois
- 22 University of Michigan | Ann Arbor, Michigan
- 23 Pennsylvania State University | State College, Pennsylvania
- 24 USDA-ARS Stored Product Insect and Engineering Research | Manhattan, Kansas
- 25 Massachusetts Institute of Technology | Cambridge, Massachusetts

CANADA, MEXICO, AND CENTRAL AMERICA

- 1 Lethbridge Research and Development Centre | Lethbridge, Alberta | Canada
- 2 University of Manitoba | Winnipeg, Manitoba | Canada
- 3 Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias | Santa Catarina, Ciudad de México | Mexico

SOUTH AMERICA

- 1 Museo Paleontológico Edigio Feruglio | Trelew, Patagonia | Argentina
- 2 Universidad de la Republica | Montevideo | Uruguay

EUROPE

- 1 Council for Research and Experimentation in Agriculture | Rome | Italy
- 2 Max Planck Institute for Plant Breeding Research | Köln | Germany
- 3 Lund University | Lund | Sweden
- 4 Perennial Grains Research Program | Lyon | France
- 5 Swedish University of Agricultural Science | Alnarp | Sweden
- 6 Swedish University of Agricultural Science | Uppsala | Sweden
- 7 University of Copenhagen | Copenhagen | Denmark
- 8 CIMMYT Turkey Wheat Program | Ankara | Turkey
- 9 Namik Kemal University | Nerjiz | Turkey
- 10 Liege University, TERRA research and teaching center | Gembloux | Belgium
- 11 University of Bonn | Bonn | Germany

AFRICA

- 1 Agricultural Research Council | Pretoria | South Africa
- 2 Jimma University | Jimma | Ethiopia
- 3 Makerere University | Kampala | Uganda
- 4 ICRISAT | Bamako | Mali
- 5 ICRISAT | Nairobi | Kenya

ASIA

- 1 Yunnan University | Kunming, Yunnan | China
- 2 Northwest A&F University | Xianyang, Shaanxi | China
- 3 Guizhou Normal University | Guiyang, Guizhou | China
- 4 ICRISAT | New Delhi | India
- 5 Makanyay Project | Ramallah | Palestine
- 6 Tel Aviv University | Tel Aviv | Israel

AUSTRALIA

- 1 New South Wales Department of Primary Industries | Orange, New South Wales | Australia