Geophysical Research Abstracts
Vol. 21, EGU2019-11576, 2019
EGU General Assembly 2019

Intercropped Woody Species in the Sahel to Resist Drought: Agronomic Performance and Soil Quality

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The Sahel is an ecologically fragile environment under threat from over population, livestock grazing, and intensification of cropping with continuing soil degradation. Drought periods during the growing season are common, causing chronic low yields, crop failures, and long-term food insecurity. This challenge will only increase with climate change. Millet and sorghum the food source for the majority Sahelian populations depend on local production and consumption. Yields of staple cereals such as millet have remained flat for more than five decades. Biologically based systems are desperately needed that utilize local resources. Such a solution is a system based on two native shrubs, Guiera senegalensis and Piliostigma reticulatum , that coexist with row crops throughout the Sahel and until recently have largely been overlooked. Unfortunately, the current management of coppicing and residue burning prior to cropping is depriving soils of much needed organic matter. Our research on the agronomic performance of an optimized, non-thermal shrub intercropping system, at 2 long-term experiments (11 years) in Senegal, showed the intriguing ability of G. senegalensis and P. reticulatum (optimized at ∼1500 shrubs/ha with return of coppiced biomass to soil) to dramatically increase yields of millet and groundnut, with or without fertilizer additions. Shrub intercropping has more than doubled carbon and increased the availability of most macronutrients in soil over non-shrub cropping. Shrubs significantly increase microbial diversity in millet rhizosphere soil and enrich genera known to have plant growth promoting properties. A key discovery is that these shrubs perform hydraulic lift (HL) which is the movement of water via deep roots from wet sub- to dry surface-soil, at night when photosynthesis stops. Long-term data showed shrubs reduce drought impacts in crops by significantly increasing rainfall water use efficiency (WUE) (kg grain ha/mm precipitation).
Recently a simulated drought experiment (with total water control in the dry season) was done by stopping irrigation at late millet flowering and no further application of water. The treatments with shrubs subjected to drought continued to maturity and produced harvestable millet, whereas non-shrub plots resulted in crop failure. The improved WUE and ability to buffer drought periods is due to improved soil quality and HL. Indeed, during the simulated drought experiment, using isotopically enriched deuterium water that hydraulically lifted water was taken up directly by adjacent millet plants - meaning shrubs are “bioirrigating” crops. Another mechanism for buffering against drought, is that shrubs reduce time to harvest by about 15 days - a valuable asset for the semi-arid Sahel. Optimized shrub-intercropping is advantageous for subsistence farmers, because it is a local resource. Fifteen years’ research shows that an optimized system regenerates degraded soils, increases crop productivity, and resists drought; critical characteristics for to address a changing climate. With the sound scientific basis of optimized shrub intercropping established and the fact that these shrubs are found throughout the Sahel – we are poised to pilot test and demonstrate this system throughout the Sahel as a key management tool for beating famine across the region.