Bioirrigation and Biofertilisation for Sustainable Intercropping of Pigeon Pea and Finger Millet

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Background

Food security for the growing population and achieving the zero hunger target by 2050 is a major challenge for humanity. Sustainable intensification of agriculture, has been proposed as a way forward to address this challenge. In this study, we propose a sustainable cereal - legume intercropping agroecosystem model employing the concept of bioirrigation and biofertilisation that could work as a model system for sustainable intensification of agriculture in rain-fed areas of Southern India. “Bioirrigation” is based on the principle of hydraulic lift (HL), where transfer of water occurs through roots from wet soil layers to dry soil. In this study, we designed an experiment to test the effects of bioirrigation and biofertilisation on the growth and yield of a intercropping system that included pigeon pea (*Cajanus cajan)* as a deep-rooting plant to bioirrigate the neighbouring shallow rooted finger millet (*Eleusine coracana*). In order to increase efficacy of water transfer from pigeon pea to finger millet, AMF (arbuscular mycorrihzal fungi) and PGPR (plant growth promoting rhizobacteria) were used as biofertiliser.

Objectives

1. Does hydraulically lifted water by pigeon pea reaches to and promotes the water relations and photosynthesis rate of finger millet?
2. Does AMF/PGPR contribute/increase the efficacy of transfer of hydraulically lifted water from pigeon pea to finger millet and support the growth of finger millet under drought condition?

Conclusions

1) Yes, hydraulically lifted water by pigeon pea reaches to and promote the water relations and photosynthesis rate of finger millet.
2) The presence of AMF/PGPR supports the growth of finger millet under drought conditions.

Experiment Set up

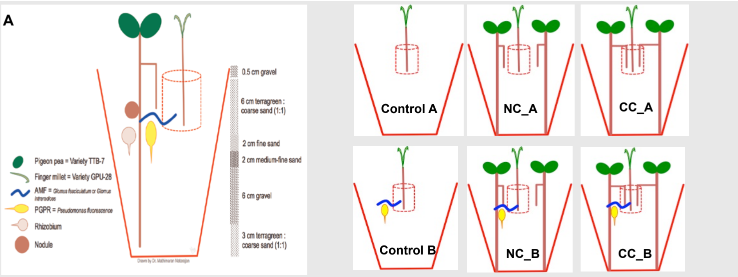

Figure 1. Pot (Figure 1A) filled with different layers of sand and gravel. Finger millet was confined to a nylon mesh compartment and could only access water through hydraulic lift supply by pigeon pea during drought period. Six different treatments: Control A & Control B: Only finger millet without and with biofertiliser, NC_A & NC_B: pigeon pea roots not connected to finger millet compartment without and with biofertiliser, CC_A & CC_B: pigeon pea lateral root connected to finger millet compartment without and with biofertiliser, respectively.

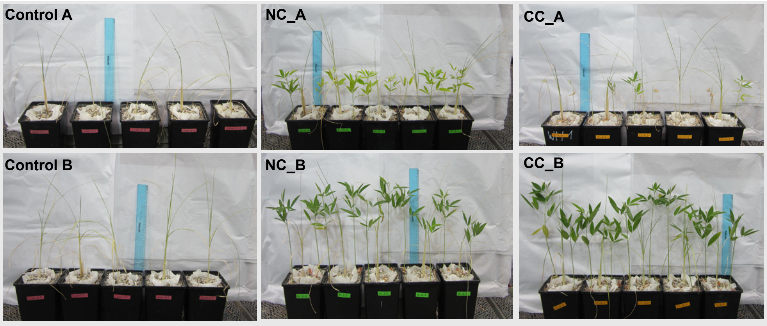

Figure 2. Plants shown in this figure are 107 days old, and it clearly shows the stress level of finger millet. Pigeon pea plants without biofertiliser showed reduced growth and, pigeon plants in split-root treatment (CC_A) without biofertiliser could not survive. However, pigeon plants in NC_B and CC_B treatment with biofertilizer showed better growth.

Results & Discussion

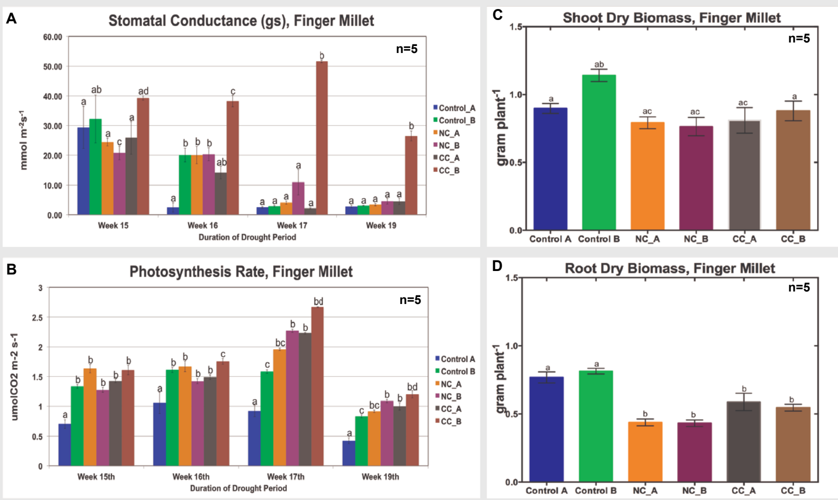

Figure 3. 3A & 3B showing Stomatal conductance (gs) and photosynthesis rate of finger millet during the drought period, respectively. Figure 3C & 3D, showing the shoot and root dry biomass of finger millet (133 days), respectively. Each treatment has five replicates. Tukey`s test (one-way ANOVA) was used for multiple comparison, values with same letters under the same week, are not significantly different at $p>0.05$.

The biomass reduction of finger millet in the presence of pigeon pea indicates the presence of competition between two species which results in less biomass production in intercropping.

The high competition between pigeon pea and finger millet could be reduced by optimizing the plantation distance in the field. The current model of mixed cropping could be an ideal approach for growing millets (shallow-rooted crops) in rain-fed areas in tropics and sub-tropics.

Methods & References

Pigeon pea and finger millet plants were grown in a pot (21 X 12.8 cm), and the pot was filled in layers with the different material (as shown in figure 1). The top compartment for finger millet was made with a nylon mesh (16 µm pore diameter) that allows mycorrihza to grow through the mesh but restricts the root to pass through. The next layer of gravel (6 cm above bottom) prevent rise of water to the top through capillary rise, the next layers of medium and fine sand (2 cm) help in retaining the moisture for long time in the top layer (terragreen plus sand). The Drought period started from week 13th and during drought period pots were watered by immersing the bottom 5 cm into the water for 15 minute and additional 10 ml of water was added to the top layer. Pots were watered at the interval of 2 days, and the experiment was continued till the end of 19th week. Photosynthesis rate and stomatal conductance were measured after 24 and 48 hours of watering.

Reference: Sekiya N & Yano K (2004) Do pigeon pea and sesbania supply groundwater to intercropped maize through hydraulic lift? Field Crops Research (86)167–173.

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