Bioirrigation, facilitated via a common mycorrhizal network, supports the water relations of finger millet in intercropping system with pigeon pea during drought

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Background

Hydraulic lift is an important ecological process where roots passively lift up water from deeper soil layers and release it into upper layers. Hydraulically lifted water can be redistributed to a neighbouring plant. In agroecological terms this process is referred to as “biorrigation”. The role of beneficial microbial inoculants such as arbuscular mycorrhizal fungi (AMF) and plant growth-promoting rhizobacteria (PGPR) as facilitating agents for bioirrigation has often been suggested but is not yet well understood. In this study, we designed an experiment to test the effect of bioirrigation and biofertilisation on the water-relations of an intercropping system that included pigeon pea (*Cajanus cajan*) as a deep-rooting plant to bioirrigate the neighbouring shallow rooted finger millet (*Eleusine coracana*). The results show that AMF plays an important role in hydraulic redistribution, and the shallow rooted finger millet was only able to utilize hydraulically lifted water in the presence of AMF. We propose that by designing suitable intercropping system based on bioirrigation, there is a great potential for reducing drought induced crop yield loss in arid and semi-arid tropics.

Objectives

1) Does hydraulically lifted water by pigeon pea reaches to and promotes the water relations of finger millet?

2) Does AMF contribute/increase the efficacy of transfer of hydraulically lifted water from pigeon pea to finger millet?

Conclusions

1) Yes, hydraulically lifted water by pigeon pea reaches to and promote the water relations of finger millet.

2) Yes, the presence of AMF increases the efficacy of transfer of hydraulically lifted water.

Experiment Set up

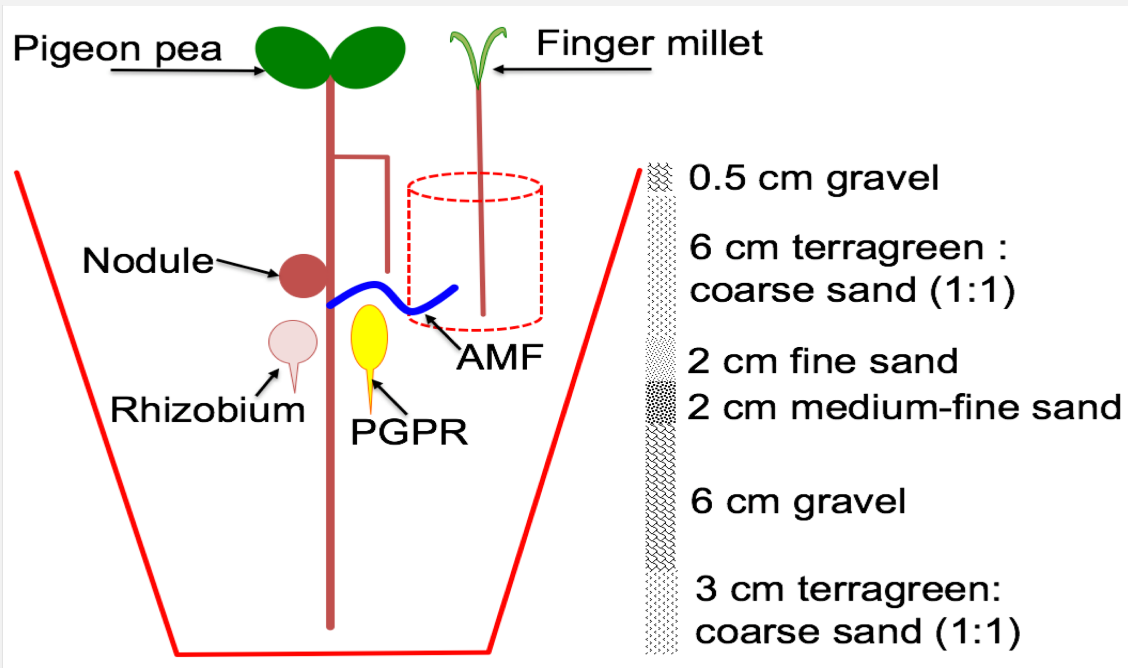
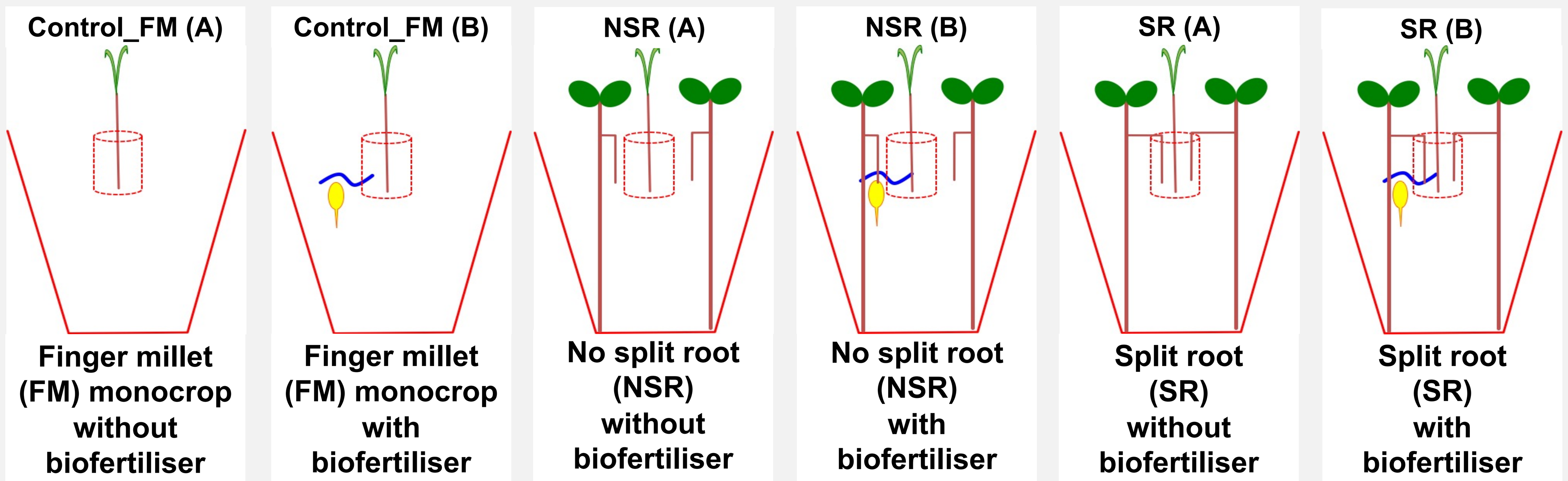


Fig. 1. Pot filled with different layers of sand and gravel.



Six different treatments without (A) and with (B) biofertiliser

Results & Discussion

Fig. 2 **Stomatal conductance (g_s) in finger millet during drought**

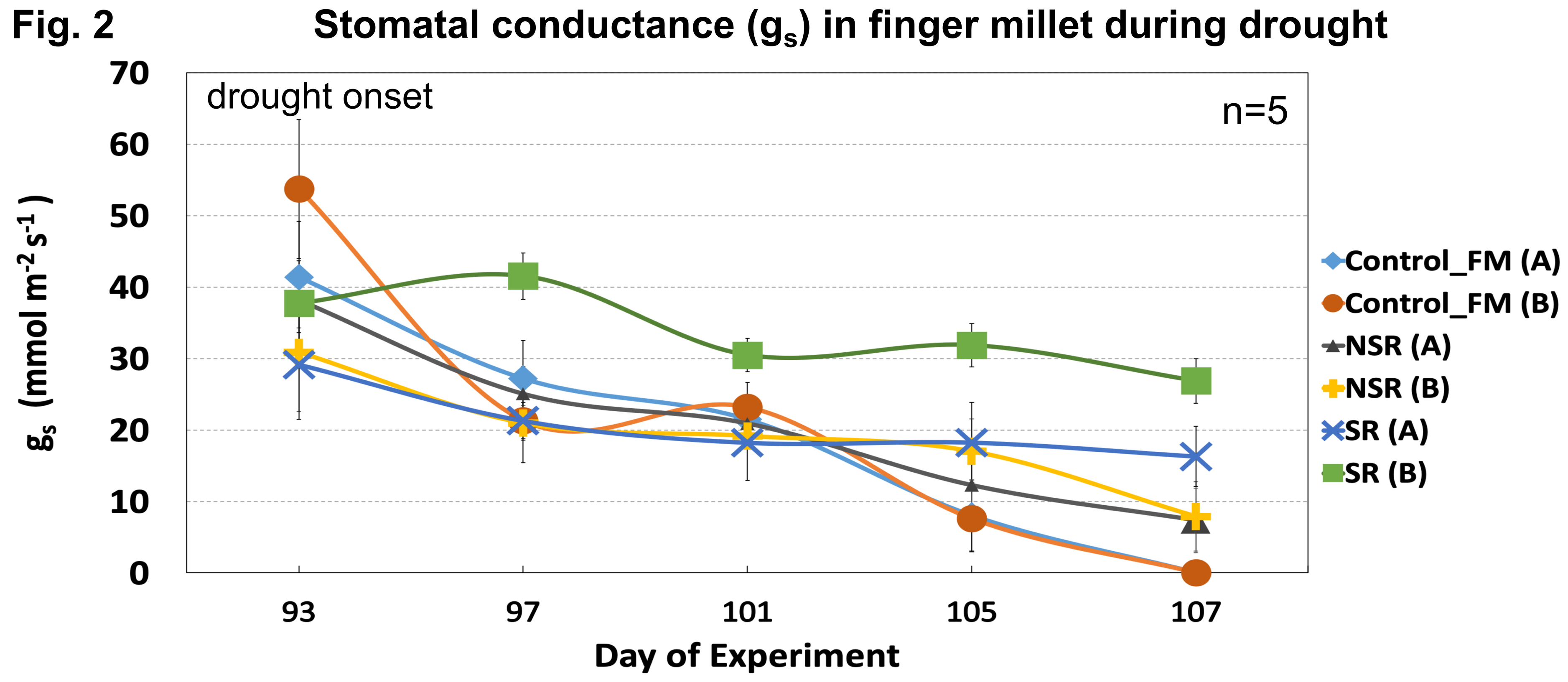


Fig. 3

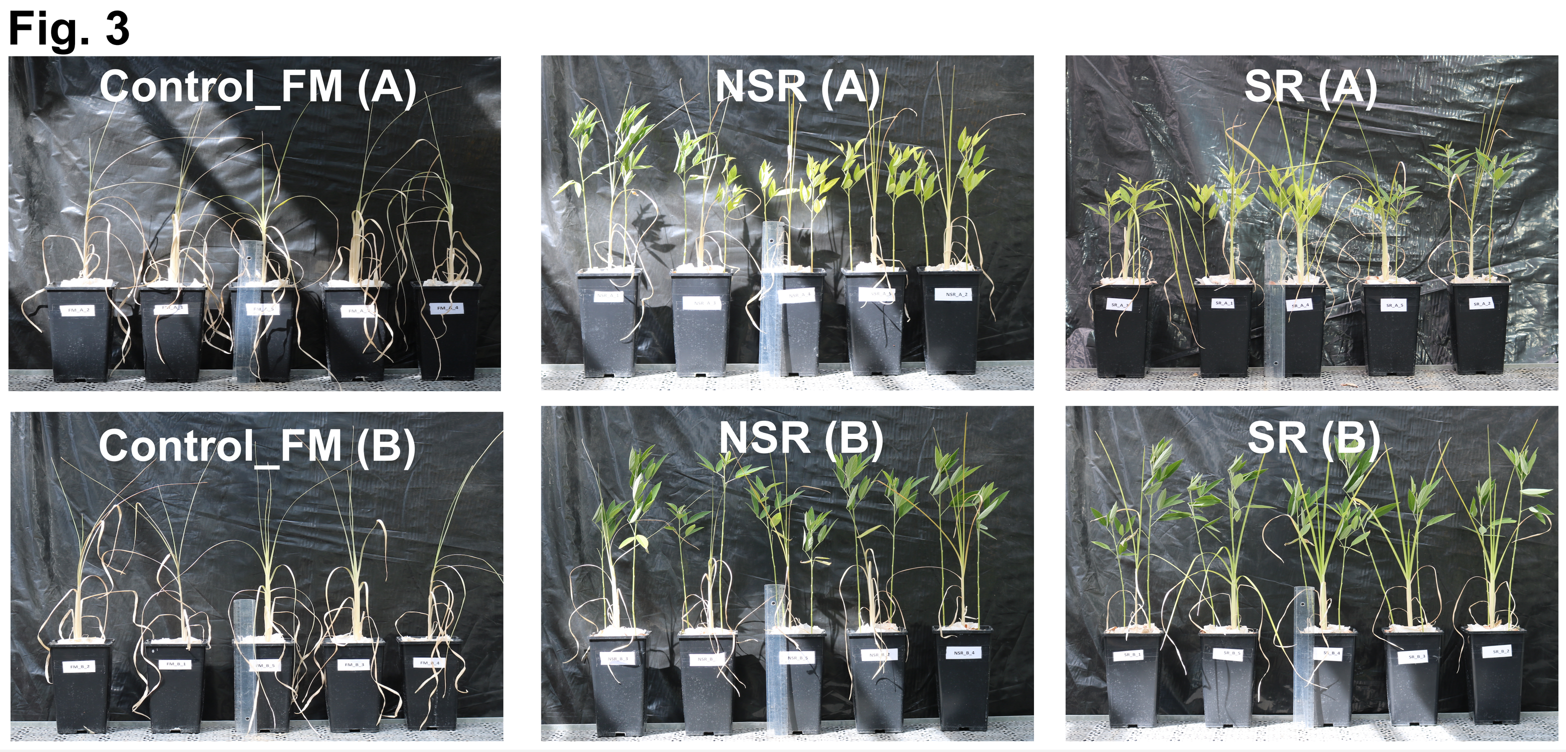


Fig. 4 **Deuterium enrichment (δ ^{2}H) in top soil layer and roots of finger millet**

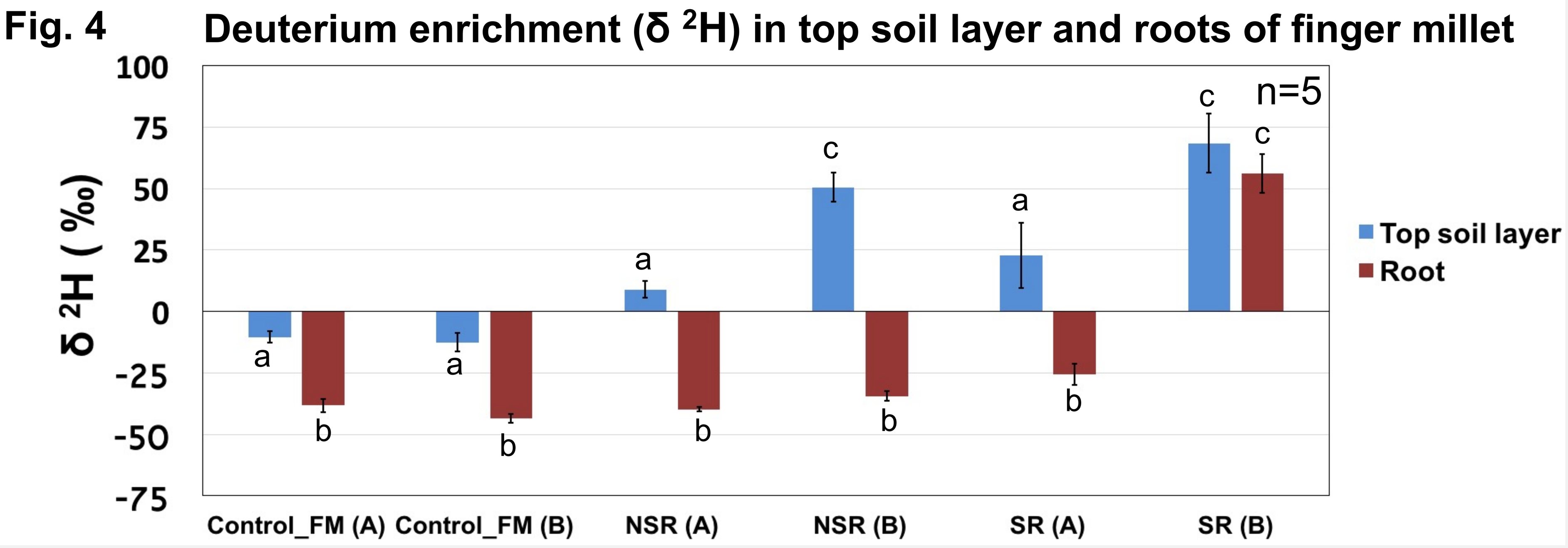


Fig. 2 Shows stomatal conductance of finger millet in different treatments during drought period. Bars represent average value of five replicates with standard error of mean.

Fig. 3 Plants shown in this figure are 107 days old, and it clearly shows the stress level of finger millet under drought.

Fig. 4 Shows deuterium enrichment in top soil layer and roots of finger millet. Treatment SR(B) shows highest enrichment into the top soil and roots that indicates the significance of AMF in hydraulic redistribution. Values with same letter are not significantly different at p>0.05 by Tukey`s test.

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 Fig. 1). The top compartment for finger millet was made with a nylon mesh (21 µm) that allows mycorrhiza to grow through the mesh but restricts the root to pass through. The next layer of gravel (6 cm above bottom layer) prevents rise of water to the top through capillary, the next layers of medium and fine sand (2 cm) help in retaining the moisture in the top layer (terragreen plus sand). The drought period was started from week 13th. During drought period pots were watered by immersing the bottom 5 cm into the water for 5 minute and additional 10 ml of water was added to the top layer. Stomatal conductance was measured after 48 hours of watering. Pots were immersed in deuterium enriched water (1280 ‰) for 5 minute and samples (soil and root) were collected after 48 hours for water extraction and measurement of deuterium enrichment.

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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