SALAM-MED sustainable approaches to land and water management in mediterranean drylands

PRIMA PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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REVITALIZE THE ARGAN ECOSYSTEM IN MOROCCO

SWRT Technology as a Sustainable Solution for Reforestation in Arid Zones

KEY MESSAGES

Subsurface retention technology (SWRT) tackles water scarcity by increasing soil moisture.

The application of SWRT significantly promoted soil fertility and argan seedling performances.

By retaining water and nutrients in the root zone, SWRT directly addresses the main cause of failure in reforestation: water stress and soil poverty.

Faced with climate change and land degradation, the SWRT represents an innovative strategy to curb erosion and restore the density of the argan forest.

The SWRT should be integrated into national argan reforestation programs to ensure high success rates and support local communities dependent on this ecosystem.

SUMMARY

The argan (*Argania spinosa*) ecosystem, vital for the economy and ecology of southwestern Morocco, is threatened by climate change and land degradation. Reforestation efforts often fail due to lack of water and low soil fertility, resulting in high mortality rates among young argan seedlings. The study conducted in the Essaouira region demonstrates that the installation of a biodegradable impermeable membrane under the root zone transforms soils into effective water and nutrient reservoirs. This situation promoted the survival and performances of argan seedlings while boosting soil health. The SWRT application could be an innovative and efficient technology to boost the success of the argan reforestation programs and the incomes of the local populations in particular women cooperatives.

RESEARCH AND RESULTS

The experimental study, conducted in the rural commune of Sidi Eljazouli (Essaouira Province), evaluated the effectiveness of SWRT on the establishment of argan seedlings in the open field. The protocol compared control soils (-SWRT) and soils equipped with biodegradable waterproof polyethylene membrane (+SWRT) installed in a "U" shape under the root zone. This configuration aims to stop the deep percolation of water and the leaching of nutrients into the soil.

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The results obtained are statistically significant and demonstrate a major transformation of soil conditions. In terms of water retention, SWRT maintained soil moisture up to 640% higher than that of control plots at a depth of 40 cm, transforming arid soil into a functional water reservoir, even during the dry months.

Agronomically, this increased retention had a direct effect on growth. Argan seedlings grown with SWRT exhibited a 168% increase in stem height, a larger canopy, and improved root biomass. The technology also promoted the retention of essential nutrients, increasing total soil nitrogen by 69% and organic matter by 51%.

Physiologically, the SWRT-treated seedlings showed increased resilience to stress by enhancing chlorophyll fluorescence and stomatal conductance. Biochemical markers indicate improved photosynthetic pigment content, higher production of protective metabolites (soluble sugars and proteins), reduced stress markers concentrations, and boost antioxidant defense, allowing plants to maintain their turgor and metabolism despite severe climatic conditions. SWRT thus proves to be an effective biological physical barrier against soil drought.

RECOMMENDATIONS

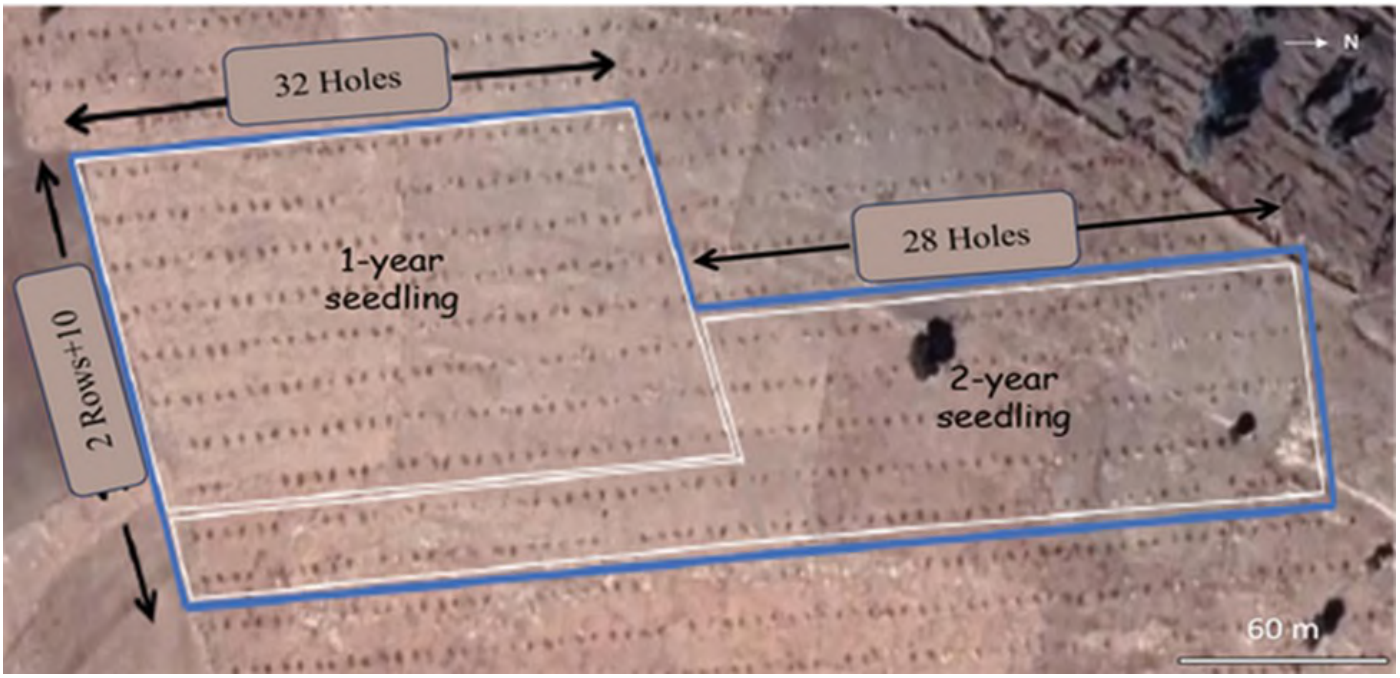
Faced with the climate emergency and the high failure rate of classic reforestation programs, the integration of SWRT appears as an essential strategic lever. Based on the established scientific evidence, we make the following recommendations:

Systemic Integration in Reforestation Programs

It is imperative to integrate the specifications of the SWRT technology into future calls for tenders from the National Water and Forest Agency and the Ministry of Agriculture, particularly for the "Green Generation" strategy. The installation of SWRT membranes must become a technical standard for any plantation of argan trees or forest species in semi-arid and arid areas.

Optimization of Water and Fertilizer Resources

Public policies should promote SWRT not only as a tool for plant survival, but also as an instrument for water saving. By reducing percolation, this technology allows spacing out the frequencies of supplementary irrigation needed during the first two years of planting. Moreover, it minimizes the leaching of fertilizers to groundwater. A specific subsidy for SWRT equipment should be created to encourage farmers to adopt this sustainable practice.



Technical Training and Technology Transfer

The implementation of the SWRT requires precise technicality (depth, aspect ratio, mechanical installation). It is recommended to launch training programs targeting forest technicians and local argan cooperatives. The creation of demonstration plots in key areas (Essaouira, Agadir, Taroudant, Tiznit, …) will serve as an educational showcase to prove the economic viability of the system to local communities.

Encourage Biotechnological Synergy

Although SWRT is effective alone, its coupling with other y technologies such as arbuscular mycorrhizal fungi (AMF) and/or compost may further maximize the outcomes. Restoration policies must promote a holistic approach: combining physical engineering (SWRT) with biological engineering (inoculation of seedlings with AMF in nursery and application of compost) to ensure recovery rates close to 100%.

Priority Targeting of Degraded Areas

Prioritize the application of SWRT in areas where the density of the argan tree has fallen below the critical threshold (30 trees/ha). This technology represents the viable solution to "revegetate" soils that have become too permeable and poor to sustain natural regeneration, thus slowing the advance of desertification.

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